This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

BUHR B
[redacted]
a39015 00019033

THE UNIVERSITY OF MICHIGAN · LIBRARIES · 1817

THE UNIVERSITY OF MICHIGAN LIBRARIES 1817

ce Library
E
48
/ 3
t. 12

of the

Association.

Science Library
QE
1
.L48
v. 3
pt. 12

Transactions of the Leeds Geological Association

This volume is bound without v.3, pt.1-11,14; v.4, pt.1-15

which is / are unavailable.

Science Library
QE
1
.L48
v. 3
pt. 12

Transactions of the Leeds Geological Association.

PART XII. 1898-99 & 1899-1900.

THE

TRANSACTIONS

OF THE

LEEDS

Geological Association.

PART XII.

1898-99.

1899-1900.

EDITED BY

DAVID FORSYTH, M.A., D.Sc.,

Hon. Secretary,

Leeds:

PRINTED AND PUBLISHED BY RICHARD CROSLAND, 69, WOODHOUSE LANE.

1900.

Science Library
QE
1
.L48
v. 3
pt. 12

GENERAL BOOKBINDING CO.
79 2 1
127AA 013 C
QUALITY CONTROL MARK
C43-246669
2088

Report of Council.

1898-99.

YOUR Council has pleasure in reporting another session of steady work and progress.

The meetings as a rule were well attended, but it was felt that considering the excellence of the papers read there might have been an improvement in this respect.

The Association now consists of 10 Honorary Members, 75 Ordinary Members, and 2 Associate Members, making a total of 87 Members. An effort should be made to increase the membership by members bringing their friends to hear the papers read, and in this way inducing them to join the Association.

Nine Evening Meetings were held, at which the following papers were read:—

1898
Oct. 20. Opening Address by the PRESIDENT (Mr. T. H. Howarth, F.G.S.) on "What we know of the Boulders of Yorkshire."

Nov. 17. "Geology at the British Association," by Mr. P. F. KENDALL, F.G.S.

Dec. 15. HOLIDAY NOTES:—
"Among the Ingleton Caves," by Mr. S. W. CUTTRISS.
"A Tour in Normandy," by Rev. W. LOWER-CARTER, M.A., F.G.S.

1899
Jan. 19. "The Grand Canon of the Colorado," by Mr. C. T. WHITMELL, M.A., B.Sc.

Feb. 16. "Views in the Appleby District," and "Views in Southern Scotland," by Mr. GODFREY BINGLEY: with Descriptions of the Geology of the Districts, by Mr. P. F. KENDALL, F.G.S., and by Mr. D. FORSYTH, M.A., D.Sc.

Mar. 16. "Some Yorkshire Erratics, and how to recognise them," by Mr. J. H. HOWARTH, F.G.S.

April 20. "The Interior of the Earth," by Mr. A. R. DWERRYHOUSE.

May 18. "The Basalt Plateau of the Faroes," by Mr. JOSEPH LOMAS, A.R.C.S., F.G.S.

Exhibits of Specimens were made by:—

Mr. WHITMELL in illustration of his Lecture.

Dr. FORSYTH, "Typical Rocks and Fossils of Southern Scotland."

Mr. HOWARTH, "Yorkshire Boulder Specimens."

Mr. J. W. BOND, "Fossil Plants from the Carboniferous Strata of Leeds."

After various papers there were interesting exhibitions of specimens, illustrative of the lectures, either of local, or of general interest.

As in former years, the Association is much indebted to Mr. Parsons for his kindness in lending his lantern on all occasions, and for his skill in manipulating it for the great benefit of the Association.

At the end of the present session it is hoped that the Transactions will be ready for Members.

As the Association has removed its meeting to the Philosophical Hall, it is but just to place on record its appreciation of the kind attention of the officials and staff of the Leeds Institute of Science and Art.

PAPERS

READ BEFORE THE

Leeds Geological Association,

SESSION 1898-99.

OCTOBER 20TH, 1898.

"WHAT WE KNOW OF THE BOULDERS OF YORKSHIRE,"

BY MR. J. H. HOWARTH, F.G.S.

Mr. Howarth began his lecture by a reference to the remarkable fund of geological interest to be found in Yorkshire:—"From the Silurian on its western borders to the Chalk on its eastern side we have, except the Devonian, the whole intervening series of geological formations, with a few not unimportant dikes and sills thrown in to illustrate igneous action." Our county is no less remarkable as affording proof of glacial times. Indeed, it seems to be a kind of "dumping ground," or haven of rest for glacial remains from all sides. The question of erratic boulders has for many years received constant attention from the Boulder Committee of the Yorkshire Naturalists' Union, under the active secretaryship of the late Mr. Thomas Tate, and the problems incidental to it have received a great stimulus from the energy and observational genius of Mr. Kendall. We can now safely state the following conclusions arrived at regarding Yorkshire boulders:—They came to us by three main routes—(1) down the Vale of York from the Tees, and down the East Coast by way of the Tees mouth; (2) over the Pennine Range from Lancashire into one, and probably two, of the South-west Yorkshire river valleys; (3) from Southern Norway and Sweden across the sea. Each of the routes is sufficiently marked by the presence of distinctive boulders, and from petrological examination we have been able to trace the districts from which they came, and in a few cases almost the exact spots.

The Tees route is marked by boulders of Shap granite, and of rocks from districts lying north of a line drawn from Whitehaven and Cockermouth to Coniston, such as St. John's Vale felsites, Skiddaw granite, Eycott Hill basalt or dolerite, granites from Southern Scotland, Carrock Fell Gabbro, and Whin Sill. The dispersion of Shap granite is an object lesson in the complicated character of glacial phenomena. It is fortunate that the rock is

distinctive and unmistakable, or the vagaries of its wandering specimens would be beyond belief. From a small outcrop of about two miles by one, it has travelled east, west, north, and south. The highest elevation of Wastdale Crag is 1,479ft. The boulders have gone north, down the Eden Valley, and directly opposite, due south, over the watershed, to Kendal, and down to Morecambe Bay. There is a boulder high up on Grayrigg Fell—1,619ft.—which is higher than Wastdale Crag. Shap granite has been found at Liverpool, in the Isle of Man, and in Northumberland. From a line due north right round to east, the boulders lie in thousands in a great fan, and two miles from its apex this fan is six or seven miles wide. The line of distribution is round by Shap village, Clifton, Penrith, Longwathby, back by Dufton to Brough; and Mr. Kendall has suggested that the boulders first went down the Eden Valley, and were afterwards driven back by the South Scotch glacier. If, however, the pressure of the South Scotch glacier was so great as to drive back boulders over the Pike and Orton, 1,100ft. to 1,200ft., it is not very clear why it did not overrun Shap village and disturb the peculiar local distribution. At any rate, it is certain that the boulders went over Stainmoor, and by the higher pass, 1,440ft. Taking along with them other distinctive rocks, they passed down the Tees, and right out to sea off Tees mouth, and are said to lie in a belt thirty or forty miles off the coast in a sinuous line parallel to the coast line, and trawlers have been reported to have brought up specimens in their nets. The glacier was deflected down the Yorkshire coast by the Norwegian ice, and in certain bays protected by a headland, as in Robin Hood's Bay, they are deposited in great numbers.

This Tees glacier was dammed back by the Scandinavian ice, but what happened in mid-Tees is not quite clear. There are several stories—(1) That the Tees glacier was divided by the Cleveland Hills, one part going on to the Tees mouth, and the other turning south through the Vale of York; (2) that it was compelled to turn back as a whole, and found a way south through the Vale of York, joining the Swaledale, Wensleydale, and Nidderdale glaciers, but after the main body of the Shap boulders had been passed out to sea; (3) that the North Sea ice not only blocked Tees mouth, but also deflected the Northumberland ice (including that which had gone by Carlisle round the north end of the Pennine Chain), and compelled it to come right athwart the course of the Tees glacier, and with it to descend the Vale of York. Much yet remains to be done before all the points of the evidence are made clear.

The boulders from Lancashire came by a very different route, pushed eastward against the Pennine Range, and eventually driven over it above Todmorden into the Calder Valley. Eskdale granite, Buttermere and Ennerdale granophyres, and Borrowdale Andesites and Ashes are plentiful. High up the valley at Todmorden and Millwood the boulders are larger and striated; farther down the valley they become smaller in size, and bear no striæ. This would

suggest that the Calder glacier did not descend far down the valley, but that its moraine materials were ultimately washed lower down. Great interest attaches to Balby, near Doncaster, where an anomalous patch of boulder clay, 40ft. thick, is found with specimens not only of rocks from the Lancashire route, but also of Shap granite by the Tees and Vale of York route! Evidently a meeting-place of boulders from the north and from the west. Royston, near Barnsley, is even more remarkable, for it suggests a meeting-place for boulders from all three routes! Quartz porphyry and Shap granite indicate the Tees route, Ennerdale granophyre and Borrowdale plumbago suggest the Lancashire route, while fossiliferous Lias and Flamborough flints and certain red and grey granites which are not British suggest a complication of the remains of the coast and of materials from the Norwegian routes.

The third route from Southern Norway and Sweden has given rise to considerable controversy. Certain rocks identical with those in Southern Norway have been found along our East Coast in great numbers. Some who have felt some difficulty in imagining an ice sheet spreading over an area so wide have insisted that these boulders were ballast brought over by early Norse invaders! Two rocks, which have been for some years clearly identified as from Southern Norway, are Augite Syenite of Laurvik and Rhomb porphyry of the Christiania district. Augite Syenite has been found at Saltburn, Robin Hood's Bay, Atwick, at Ferriby, and at Louth, in Lincolnshire; Rhomb porphyry at Staithes, Robin Hood's Bay, Atwick, Patrington, Burstwick, Willerby, and other places. The facts associated with these two rocks prove conclusively that Scandinavian ice reached our shores. Other evidence is also accumulating. At Easington there has been found a boulder of Post Archæan granite, which has been identified by Dr. Munthe, of Upsala University, as coming from the shores of the Baltic. Glaciated boulders of chalk are found in the East Riding, which contain the fossil Bellemnitella lanceolata, unknown in Yorkshire chalk, and they have been found at Scarborough, twenty miles north of the chalk cliffs of Yorkshire. Mr. Kendall spent a month in Norway last year, between Christiania and Christiansand, and made a splendid collection of rocks for comparison with our Yorkshire erratics, and he took over with him some East Coast boulders from Mr. Stather's collection, and submitted them to Professor Brogger, who positively identified some of them. Every opportunity should be made use of for extending our knowledge of boulders, wherever boring or cuttings are made in the county. The drift of the Aire Valley is close at hand, and it would be interesting to know whether ice from the Ribble Valley, and even Ingleton, got into the Aire Valley over the low watershed between Hellifield and Bell Busk; microscopic examination would tell us whether the limestones in the drift came from Kettlewell or Malham, or Settle and Stainforth. Phillips told us long ago that the specific gravity of the limestone differs very appreciably, and that method of investigation might be followed up with interest. Indeed, interest

lies all round such questions.

Age cannot wither, nor custom stale
Their infinite variety.

The paper was illustrated by maps, diagrams, and lantern slides, and was listened to with unabated interest to its close.

Mr. Godfrey Bingley followed with a fine series of slides illustrative of much industry and artistic activity during the summer. Scenes from Yorkshire, Berks, Herts, London, and Windsor, and river scenery on the Thames, all passed in delightful succession before the admiring eyes of the members.

NOVEMBER 17TH, 1898.

"GEOLOGY AT THE BRITISH ASSOCIATION,"

By Mr. P. F. KENDALL, F.G.S.

Mr. Kendall particularly called attention to two noteworthy papers—those by Mr. Oldham, of the Indian Geological Survey, and by Professor Milne, a native of Yorkshire. Referring to the latter's paper, he said that, according to Professor Milne, 75 per cent. of the known earthquakes could be localised to the edge of the great sub-oceanic Continental Shelf. It was here that the telegraph cables were most frequently broken. The observation of earthquakes is still continued in the Isle of Wight. Professor Milne keeps a continuous record of all earth tremors, and can predict, from the nature of the tremor, the distance of the focus. It is found that Japanese earthquakes show in the Isle of Wight preliminary tremors lasting half-an-hour, while those from Borneo last forty minutes. Professor Milne's observations fully confirmed his early suggestion that the high velocity of propagation of earthquake waves is ascribable to the excessive rigidity of the materials composing the interior of the earth.

This paper was supplemented by another by Mr. Oldham, of the Indian Geological Survey, in which what is termed the Calcutta earthquake (although Calcutta was not over its focus), was described as the greatest earthquake shock in area that has been yet observed; and in which also attention was called not only to alterations in altitude, but to horizontal movement of hills caused by that earthquake.

A contribution by Professor Hull pointed out the interesting observation that the mouths of the great rivers flowing into the Atlantic corresponded with observed indentations in the submarine plateau which fringes the continents. Professor Kendall instanced such indentations as correspond with the mouths of the Adour and the Congo and the deep gully along the English Channel. He pointed also to the greater inclination of the seaward edge of this continental fringe, and that there was the region of greatest displacement or shift, as indicated by earthquake action.

Mr. Kendall next called attention to the paper of Mr. J. H. Holland, of the Indian Geological survey, in which were stated the results of a long series of observations made on the decomposition of rocks in the Deccan. The Deccan has been a land area from very early geological times, and Mr. Holland's observations, that the upper decomposed, or rotted rock zone was abruptly succeeded by a lower solid zone (in which minerals were in fresh crystalline condition) led him to form the conclusion that decomposition of deeper rocks is only possible where the high pressure of the water of a superincumbent ocean has induced chemical action. Similar observations and conclusions have been made regarding the Canadian area.

In Stratigraphical Geology, Mr. Kendall alluded briefly to the discovery by Professor Coleman (Toronto) of interglacial deposits of strata with a fossil flora, indicative of a temperate climate; and to that of Mr. Lomas of flints found in glacial strata. In the same connection he also alluded to the work of Mr. Greenley in the Moel Tryfaen area, and the uplifted boulders of Anglesea, and also to that of the Rev. Mr. Pollan on the Ty Newydd Caves.

With relation to work in Carboniferous Strata, Mr. Kendall reminded members of the excellent work done among the Eccup shales, and of the fine series of millstone grit fossils—cephalopoda, brachiopoda, and trilobite—that had been found so near Leeds. He called attention also to the paper of Mr. Etheridge regarding the extension of the coal measures under the newer rocks in the south-east of England—a subject not only of great geological interest, but one that might have an important bearing on the industrial development in the future of that district.

In criticising the paper of Mr. Wethered on the Oolitic structure of rocks, Mr. Kendall thought that while in some cases this peculiar structure was due, as Mr. Wethered contended, to encrusting organisms (confervæ, or algæ), there were many other cases in which this structure was due to chemical and mechanical segregation.

HOLIDAY NOTES.

DECEMBER 15TH, 1898.

Mr. S. W. Cuttriss read an interesting paper upon the "Ingleton Caves," in which he detailed a series of continued explorations of the "pots," and caverns of the district. He first referred to the complete isolation of Ingleborough as a drainage area, and showed that all the streams rising near the summit disappear beneath the surface when they pass on to the mountain limestone. He next summarised the results of the first complete explorations and surveys of Yordas Cave, and Bull Pot, both in Greygareth. The main work of the year, however, had been devoted to the chasms upon Leck Tell; here the party had explored Rumbling Pot, Death's Head Pot, and Lost John's Cave. The first of these was entered

and explored on Whit-Monday, while the last was, after many attempts, only conquered on September 28th and 29th of this year. Mr. Cuttriss's paper was illustrated by an admirable series of slides, many of the views having been taken under conditions of great difficulty.

The Rev. W. L. Carter, M.A., F.G.S., read a paper brimful of interesting geological, historical, and ethnological information; taking Caen, Mont St. Michel, and Avranches as centres, he described, and illustrated by lantern slides, the main objects of interest which could be seen by a cyclist or pedestrian, within a limited holiday.

JANUARY 19TH, 1899.

"THE GRAND CANON OF THE COLORADO OF THE WEST,"

BY MR. C. T. WHITMELL, M.A., B.Sc.

Mr. Whitmell began by stating that, as some confusion appears to exist in reference to the Yosemite Valley, the Yellowstone Park, and the Grand Canon of the Colorado, he would be careful to point the exact position of the canon on the map. The Colorado River is formed by the junction of the Grand River with the Green River in South-Eastern Utah; both of these streams originate in Alpine lakes, and are fed by everlasting snows. Below the junction the Colorado proper flows in a south-westerly direction through Utah and Arizona, southwards between Nevada and California on the west and Arizona on the east, and falls into the Gulf of California after a course of about 2,000 miles. The lower portion of the river, about 600 miles long, is navigable, and but little above sea level; the upper part flows through an elevated region from 4,000 to 8,000 feet high. The upper streams, born in the mountains, course through the plateaux, where the climate is extremely dry; and, there being in this arid district much vertical, and but little lateral erosion, the streams cut deeper and deeper, forming gorges with towering walls of rock; these gorges are called canons. For more than a thousand miles the Colorado has cut such a canon, or rather a series of canons; the longest measures about 220 miles. In some portions of its course the speed of the stream is said to equal that of an express train. The region is diversified by short ranges of eruptive mountains, and a vast system of fissures extends across the country; from these floods of lava have poured, covering the plateaux with sheets of black basalt. Huge cinder cones stand along the fissures, contrasting strongly with the variegated sedimentary rocks. Eocene rocks cap the summit of the plateaux region, then emerge successively Jurassic, Triassic, and Permian, in terrace after terrace, until the broad platform of the Carboniferous is reached. A very characteristic feature of the scenery is due to the Buttes—lofty, more or less

detached, stacks or pyramids of horizontally stratified rock, their isolation being due to the recession of the heads of adjacent valleys which meet at a col or pass. But the strangest feature of this strange region is the way in which it is trenched by profound ravines, on a scale of grandeur unparalleled. The country is hardly to be crossed except by birds, for not only does the main stream form a gorge, or succession of gorges, but each tributary runs in a similar gorge. Each of these branches into side canons, and these again subdivide, until some parts of the district look like piles of colossal ruins. The deepest part of the Grand Canon sinks to 6,000 feet, more than a mile below the surface. The Canon is often double, the upper part being five or six miles wide, bounded by noble cliffs 2,000 feet high; at the base of these is a platform, through which winds the inner chasm, a narrow ravine, some 4,000 feet wide, sunk to a depth of 3,000 feet below the platform. There is no evidence of subterranean movements having opened or deflected the course of these defiles. They are due to erosion, not to cataclysms. The strata can be traced unbroken from side to side.

Mr. Whitmell showed by lantern slides the nature of the rock terraces on the sides of the ravines. They consist of an alternating series of steep vertical cliffs or ledges, and short slopes. Along each slope, at the foot of each cliff, is a talus of debris fringed with vegetation, while the ledges are evidently of material much harder than the slopes. Near Diamond Canon he pointed out the succession of strata as 600 feet of massive granite (or rather metamorphosed schist) at the base, then a series of beds of limestone shale and sandstone for about 1,600 feet, and on the top about 1,000 feet of coralline limestone.

The return journey form the Grand Canon was made by way of San Francisco, and involved the crossing of the Desert, where in the sun the thermometer stood at 130 degrees, and in the shade, at 107 degrees. The vegetation in some parts of the Desert was very interesting—the Yucca plant being especially abundant, and several kinds of cacti. A sandstorm that lasted for an hour, and filled everything with grit, was a desert experience not to be forgotten. At night in such a dry, clear atmosphere the heavens were studded with brilliant stars.

The lecturer referred to the expedition, in 1869, of Professor Powell (now Director of the U.S.A. Geological Survey), which traversed in boats the whole length of the canon, a water journey of about 1,000 miles, in 98 days, through a narrow gorge filled with rapid cataracts. An heroic exploit! Mr. Whitmell also quoted from the Report (1857-8) by Dr. Newberry and Lieutenant Ives; from Captain Dutton's splendid Monograph, describing the results of his work in 1880; and from the writings of Sir A. Geikie.

The lecture was illustrated with numerous lantern slides, drawings, maps, diagrams, and specimens, and was listened to with rapt attention by the members.

FEBRUARY 16TH, 1899.

"VIEWS IN THE APPLEBY DISTRICT, AND IN SOUTHERN SCOTLAND,"

BY MR. GODFREY BINGLEY,

WITH GEOLOGICAL DESCRIPTIONS,

BY MR. P. F. KENDALL, F.G.S., & MR. D. FORSYTH, M.A. D.Sc.

After the transaction of the usual business, the Secretary read a letter from Mr. C. D. Hardcastle, in which he asked the Council to accept a copy of the first edition of Sir Charles Lyell's "Principals of Geology" as an addition to the Library. This gift from one of the oldest members of the Association was gratefully accepted.

The President then, in a few words, introduced Mr. Godfrey Bingley, who proceeded to give two series of views of great geological and artistic interest. The first set of slides referred to the Appleby district, and in the unavoidable absence of Mr. P. F. Kendall, F.G.S., the description of the geological features of the locality was undertaken by Mr. A. R. Dwerryhouse, F.G.S.

The series commenced with several views of the picturesque town of Appleby, which were succeeded by a series of pictures taken near Hoff Beck. The eastern bank of the beck is formed by a double escarpment, the lower step being composed of calcareous sandstones of the Carboniferous series, and the upper one consisting of the basement conglomerate of the Permian system, locally known as Brockram. This conglomerate consists largely of pebbles of the Carboniferous limestone, embedded in a red sandy matrix. This rock was also seen in Hungrigg's Quarry, nearer to the Cross Fell Range; here also the pebbles consist almost entirely of Carboniferous limestone. In Hilton Beck is to be seen a thin bed of Brockram, which is much higher in the series, and in this case, in addition to the pebbles found in the Lower Brockram, there are a large number consisting of quartzite, derived from the basement beds of the Carboniferous limestone which occur on Roman Fell, showing that while the Carboniferous limestone alone furnished pebbles to the Lower Brockram, during the deposition of the upper bed the basement strata of the Carboniferous series were exposed by denudation—probably aided by a movement of the great Pennine Fault—and contributed to its formation.

A number of slides followed showing the series of hills known as the Pikes, formed by the hard rocks of the Ordovician and Silurian age, which compose the Cross Fell inlier. The position of the great outer Pennine Fault was clearly seen in a picture of Dufton Pike. High Cup Gill is a deep V-shaded valley cut into the Carboniferous rocks of the Cross Fell Range, the lips of the valley being formed by vertical cliffs of columnar basalt. This basalt is part of the great intrusive sheet known as the Whin Gill. Angill Beck, near

Brough-under-Stainmore, was also illustrated; this consists of a canon cut through lower Carboniferous rocks, the bedding of which is almost vertical. At the top of the gorge the stream has washed out a bed of shale, and flows between vertical walls of calcareous sandstone, these being the original bedding planes of the rock. Several views of the Shap granite quarries and the neighbourhood concluded the series.

One view on the Birk Beck, close to Shap Wells Hotel, showed the Carboniferous basement beds, which locally contain fragments of the Shap granite. This granite has baked the Silurian rocks with which it is in contact, and it is seen to have contributed pebbles to the basal Carboniferous rocks. Its intrusion must, therefore, have taken place after the formation of the Silurian, and before that of the Carboniferous rocks; that is to say, during the period which is represented in other parts of Britain by the Old Red Sandstone rocks.

The second series of views were of Scottish scenery, and Dr. Forsyth pointed out the leading geological features of each picture. The first set referred to Edinburgh, and allowed on opportunity of stating the general characteristics of the volcanic necks (Arthur's Seat and the Castle Rock) in the lower Carboniferous formation. Next on the screen were thrown views of Loch Lomond, and in the description, allusion was made to the formations—Carboniferous, Old Red Sandstone, and metamorphosed Silurian—exhibited in this area, as well as to the interesting glacial features of the lake. Mr. Bingley showed next some views of Ayr and the Burns country, Greenan Castle, Heads of Ayr; and the doctor briefly described the formation of that part of the country, with its eruptive rocks bursting through the Carboniferous, or contemporaneous with the Old Red Sandstone, and the strange intermingling of Carboniferous and Old Red Sandstone fossils south of the Heads of Ayr. A few fine views of Arran, in the same way, led to a brief description of the granitic boss of Goat Fell, the metamorphic rocks circling round it, the Carboniferous limestone of Corrie, and the denudation of the glens. Dr. Forsyth illustrated with sections, maps, and fossils the next set of views, the Gervan and Ballantrae district, and dwelt lovingly on the geological problems still waiting solution there—Silurian shales, flags, and conglomerates, old volcanic ashes of Arenig age, serpentines of uncertain age, metamorphosed volcanic rocks, dykes of Miocene times, and supposed Permian rocks—all waiting observing eyes and willing hands. Another set, showing "The Crockett Country," by Dalmellington, Carsphairn, Dalry, and New Galloway, was a revelation of a new land to most of the members, and the remarkable geological character of the district, in which Dr. Forsyth had for many years done original work, was made specially clear by large working maps of his investigations. Mr. Bingley brought his series to a conclusion by exhibiting slides from the Dumfries district—Devorgilla's Bridge (of great antiquity), Burns's Mausoleum, Sweetheart Abbey, New Abbey, and Caerlaverock Castle, whose ruined towers formed a fitting close for such an artistic treat.

Mr. S. W. Cuttriss exhibited a few slides of Malham Cove (taken by magnesium light), kindly lent him by the Rev. G. H. Brown, Giggleswick.

Mr. J. W. Bond exhibited a beautiful specimen of stigmaria from Victoria Pit, Bruntcliffe, in which the cross-section showed the position and structure of the vascular bundle very beautifully.

MARCH 16TH, 1899.

"SOME YORKSHIRE ERRATICS AND HOW TO RECOGNISE THEM,"

BY MR. J. H. HOWARTH, F.G.S.

The monthly meeting of the above Association was held in the Society's Rooms on the evening of Thursday, March 16th, Mr. Washington Teesdale, F.R.M.S., in the chair.

An interesting and original petrological lecture on "Some Yorkshire Erratics, and how to recognise them," was given by the President, Mr. J. H. Howarth, F.G.S. The lecture was supplementary to one given at the early part of the session on "What we know of Yorkshire Boulders." The conclusions now arrived at concerning the sources and routes of the Yorkshire boulders was that they came to us by three main routes:—(1) Down the Vale of York from the Tees, and down the East Coast by way of the Tees mouth; (2) over the Pennine Chain from Lancashire into one, and probably two, of the south-west Yorkshire river valleys; (3) from Southern Norway and Sweden across the North Sea. Petrological examination of the Yorkshire boulders was the strongest possible confirmatory evidence of their origin. The appearance of rocks under the microscope was as a rule characteristic—*e.g.*, the feature of the Eskdale granite was that the felspars act as a matrix to the quartz. Boulders found at Blackpool and also in the Calder Valley showed the same characteristic feature, thus conclusively proving their source. By a magnificient collection of microscopic slides exhibited by the lantern polariscope, kindly lent by Mr. Branson, Mr. Howarth summarised the distinctive microscopic features of Shap granite, Skiddaw granite, Dalbeattie granite, Criffel granite, Creetown granite, Buttermere granophyre, Ennerdale granophyre, Carrock Fell gabbro, Eycott Hill dolerite, Whin Sill dolerite, and the Norwegian Rhomb porphyry, and for comparison showed sections obtained from Yorkshire boulders, which served as positive identification of the source of the Yorkshire erratics.

APRIL 20TH, 1899.

"THE INTERIOR OF THE EARTH,"

BY MR. A. R. DWERRYHOUSE, F.G.S.

Mr. A. R. Dwerryhouse stated that his objects in bringing this subject before the Association were to point out how unsatisfactory

were the methods which had up to the present time been used for the purpose of estimating the duration of geological time, and to call attention to certain apparent contradictions which appear in the various theories regarding the physical condition of the interior of the earth, now accepted by many geologists. For the purposes of the paper, the age of the earth was understood to mean the length of time which had elapsed since the surface of our planet became suitable to support life. It was pointed out that since the earliest known fauna, that of the Lower Cambrian Rocks, or "Olenellus zone," was very varied, and included many very highly specialised types, the dawn of life must be placed considerably further back than the commencement of the Cambrian Period.

The various methods employed in drawing up estimates of the duration of geological time were somewhat fully discussed, special attention being given to those based upon the secular cooling of the earth, tidal retardation of the earth's rotation, the duration of solar energy, the time required for organic evolution, and the time required for the deposition of the sedimentary rocks. Attention was called to the fact that the calculations based upon the secular cooling of the earth involved the use of the temperature gradient of one degree Fahrenheit per fifty feet descent below the earth's surface, which, according to Sir Joseph Prestwich, is the mean of all observed mines and wells available, and it was pointed out that out of the 247 localities given in his memoir, 238 (an overwhelming proportion) were in the northern hemisphere; further, that all calculations assumed that the rate of cooling has been uniform, and that the conductivity of the rocks at great depths is the same as the average conductivity of surface rocks. It was also shown that the average gradient was the mean of figures which even within the limits of north-western Europe vary considerably, *e.g.*:—

Dunkirk 1 degree F. per 235 feet. Bootle (Liverpool) 1 degree F. per 153 feet. Sheerness 1 degree F. per 34 feet.	(Prestwich)

With regard to calculations based upon tidal retardation, there is no agreement among astronomers as to the amount of this retardation, and consequently it is somewhat premature to use this as a criterion of the earth's age. The question as to whether the limits placed upon geological time are consistent with the time required for organic evolution and for the deposition of the sedimentary rocks was then considered. The calculations founded upon the present rate of denudation and deposition, so far as these can be ascertained, show that the time required for these processes is considerably in excess of that indicated by physical calculations.

In the second part of the paper, dealing with the physical condition of the earth's interior, a brief history of the theories of the earlier writers was given, the views of Leibnitz and Buffon being cited as examples. The writer was of opinion that the deeper parts of the earth consisted largely of metals, among which iron played

an important part, citing in support of this view the iron-bearing basalts of Greenland, and the fact that the density of the earth as a whole is between 5 and 6, that of water being taken as unity, while the average density of surface rocks was only about 3 compared with the same standard. Many objections were pointed out to the various theories which required that the interior of the earth should be in a liquid state, and the conclusion was that the earth as a whole is solid, but that the temperature in the interior is higher than the melting point of rocks on the surface, but that the materials are kept in the solid state by pressure, anything causing disturbance of the balance tending towards local fusion.

The lecturer concluded by pointing out how extremely imperfect our knowledge of these matters still is, and by urging his hearers to devote their energies to this interesting field of scientific research.

MAY 13TH, 1899.

"THE BASALT PLATEAU OF THE FAROES,"

BY MR. JOSEPH LOMAS, F.G.S.

Mr. Joseph Lomas, A.R.C.S., F.G.S., President of the Liverpool Geological Association, read a paper on "The Basalt Platean of the Faroes." The Faroe Islands are twenty-six in number. They form a general N.W. and S.E. Besides the main fiords which divide the groups from each other, there are numerous other fiords which run far into the land. It is a significant fact that nearly every closed fiord running towards the north has a counterpart from the north running south, and the two arms sometimes almost meet in the middle line, forming low isthmuses. This configuration is due entirely to erosion by water and ice. The slopes of the mountains usually descend in great steps towards the sea. The cliffs are very steep, and but few places exist where landing is possible. Myling Head is a magnificent spectacle, rising 2,000 feet above the sea. The ceaseless mining of the sea has worn out many caves and natural arches, and, when these fall in, isolated stacks or Drangas are formed, fringing the shores. There are no streams of any importance in the islands, and only a few small lakes, or tarns. Evidence of volcanic activity during Tertiary times is seen in the basalts of Antrim, Mull, Skye, Faroes, and Iceland. This line may represent a rift, or fissure, or a line of weakness, along which volcanic rents distributed volcanic material in great flows. The Faroes are but remnants of a great volcanic plateau, cut and carved by marine and sub-aerial agencies into a cluster of islands. These volcanic flows were not constant, but often intermittent. Old land surfaces, with soil and signs of vegetation, speak of the intervals which elapsed between the successive outpourings of the lava. The lofty cliffs afford excellent sections for the study of the lava flows. The beds

vary in thickness up to about 100 feet, the upper and lower surfaces being, as a rule, amygdaloidal, and in the cavities are found the secondary minerals for which the Faroes are so celebrated—such as opal, chalcedony, stilbite napolite. The basalts vary much in colour, from black to brown. They show a large proportion of olivine, while crystals of felspar, augite, and labradorite are very common. Dykes are extremely abundant, and consist mostly of fine grained basalt. The basalts are frequently columnar, and the columns present a great variety of forms. Often in the middle of the amygdaloidal layers patches of compact basalt occur, and seem to be intrusions into the softer rock. Such intrusions may, perhaps, be described as laccolites. Sometimes a layer of hot basalt had flowed over an old soil, and produced rocks of the nature of red-baked earth. At other places thin beds of coal were found, resembling anthracite, and showing that between the flows of basalt such time had elapsed as had enabled vegetation to grow abundantly. Glacial phenomena are seen on all sides, striæ are visible wherever the soil or turf is removed, and the trend of the striæ is generally parallel to the line of direction of the fiords. The interior valleys present smooth flowing slopes, studded with polished bosses of basalt, roches moutonnées, and near the inhabited districts the smooth bosses of rock are used in the salting and curing of fish—the only industry of the islands. The Faroes may be called the Land of Cirques, for there they abound in countless numbers, and many of them are perfect in form. Sometimes they are simple cirques, or basin-shaped heads of valleys; sometimes a valley has a cluster of cirques connected with it. There can be no doubt that the cirques occupy valleys previously produced by stream action. The stream cuts like a vertical saw, and produces a V-shaped valley in its upper reaches, but a glacier, acting both vertically and horizontally, fills the valley and excavates it on all sides. The slopes of the cirques are generally covered with a fine red clayey soil, supporting a good crop of grass, and often they are the only places where grass grows in the islands. Stepped cirques, showing a succession of formations, are seen in some of the islands. Glacial mounds are found in profusion, and consist of conical hills composed of rounded and angular stones. There are no moraines, as probably the glaciers carried out their burdens to the sea. Boulder clay is but rarely found. Boulders are found in profusion, but none of them is of foreign origin. The cliffs, particularly in the west and north, are exposed to the full fury of the Atlantic storms, and denudation is going on at a very rapid rate.

JUNE 13TH, 1899.

ANNUAL GENERAL MEETING.

The Annual General Meeting of the Association was held in the Leeds Institute of Literature, Art, and Science, on the 13th June. In the absence of the President, the chair was taken by Mr. P. F. Kendall, F.G.S.

The report of the Sub-Committee regarding the negotiations with the Philosophical Society for the use of rooms was read by Mr. Parsons. The Secretary, Dr. Forsyth, read a letter from Mr. Husband, Secretary of the Philosophical Society, stating the conditions under which the Leeds Geological Association could occupy a room in their premises. After careful consideration it was unanimously agreed, on the motion of Mr. C. D. Hardcastle, seconded by Mr. Godfrey Bingley, that the terms be accepted.

The following officers were appointed for the next session :—

President: J. H. HOWARTH, F.G.S.

Vice-President: P. F. KENDALL, F.G.S.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretaries: DAVID FORSYTH, M.A., D.SC., AND WALTER PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council: JAMES E. BEDFORD, F.G.S., GODFREY BINGLEY, JOHN W. BOND, A. R. DWERRYHOUSE, B.SC., C. D. HARDCASTLE, E. HAWKSWORTH, B. HOLGATE, F.G.S., J. INGLEBY, REUBEN NUNNS, C. T. WHITMELL, M.A., B.SC.

List of Presidents.

	PROF. L. C. MIALL, F.R.S., F.L.S.
	PROF. A. H. GREEN, F.R.S., F.G.S.
1881-82	BENJAMIN HOLGATE, F.G.S.
1882-84	WILLIAM CHEETHAM, F.G.S.
1884-86	THOMAS W. BELL.
1886-88	C. D. HARDCASTLE.
1888-90	JAMES E. BEDFORD, F.G.S.
1890-92	CHARLES BROWNRIDGE, F.G.S.
1892-94	JOHN INGLEBY.
1894-96	REV. W. LOWER-CARTER, M.A., F.G.S.
1896-98	PERCY F. KENDALL, F.G.S.
1898	J. H. HOWARTH, F.G.S.
1899	GODFREY BINGLEY.

List of Officers.

1899-1900.

President: GODFREY BINGLEY,

Vice-President: P. F. KENDALL, F.G.S.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretaries: D. FORSYTH, M.A., D.SC.,
W. PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council:

JAS. E. BEDFORD, F.G.S.,
J. H. HOWARTH, F.G.S.,
JOHN W. BOND,
C. T. WHITMELL, M.A., B.SC.
A. R. DWERRYHOUSE,
C. D. HARDCASTLE,
E. HAWKSWORTH,
B. HOLGATE, F.G.S.,
JOHN INGLEBY,
REUBEN NUNNS.

LEEDS GEOLOGICAL ASSOCIATION.

BALANCE SHEET, JUNE 30TH, 1899.

Receipts.

	£	s.	d.
To Cash in hand, July 1st, 1898 ...	10	10	3
„ Subscriptions	15	17	6
„ Subscriptions in advance for 1899-1900	0	5	0
	£26	12	9

Expenditure.

	£	s.	d.
Sept. 19th, 1898, By Lantern Screen ...	0	10	0
Nov. 15th, „ „ Reading Lamp ...	0	4	9
Jan. 28th, 1899, „ R. Crosland ...	11	2	6
June 24th, „ „ Rent of Room ...	1	2	6
„ „ „ „ Rly. Ex. Lomas L'pl	0	12	8
„ „ „ „ Caretaker	0	5	0
„ 28th, „ „ Secrety's Expenses	3	15	3
„ „ „ „ Treasurer's do.	0	7	10
„ 30th, „ „ Yorks. Nat. Union years 1898-99	0	16	0
„ „ „ „ Balance in hand ...	7	16	3
	£26	12	9

S. W. CUTTRISS, *Hon. Treasurer.*

Report of the Council,

1899-1900.

YOUR Council has pleasure in reporting that the Session has been marked by earnest work and steady progress. The change of rooms has added much to the comfort of the members, but has not been followed by the increase of membership that was expected from the change. Members might aid in this matter by making known the character and aims of the meetings, and by inducing their friends to come.

Except during the exceptional wintry weather, the meetings were fairly well attended; and the papers were of more than ordinary interest.

The Association now consists or 10 Honorary Members, 58 Ordinary Members, and 2 Associates.

Eight Evening Meetings were held, at which the following papers were read:—

1899

Oct. 25. Lecture by Mr. P. F. KENDALL, F.G.S., "Geology at the British Association."

Exhibition of New Lantern Slides of the "Shakespeare Country," by Mr. GODFREY BINGLEY (President).

Dec. 20. Lecture by Mr. J. H. HOWARTH, F.G.S., "Sources of the River Aire." On this occasion Mr. F. W. BRANSON, F.I.C., and Mr. P. F. KENDALL, F.G.S., explained the Chemical and Geological Explorations at Malham, and Mr. BINGLEY exhibited a series of slides of the District.

Jan. 17. Lecture by Mr. J. W. STATHER, F.G.S., President of the Hull Geological Society, "The Divisions of the Cretaceous Series in Yorkshire," illustrated by specimens, and lantern slides.

Feb. 21. Mr. GODFREY BINGLEY exhibited "The Geological Photographs of the British Association;" and several members spoke on the districts illustrated.

Mr. J. W. BOND exhibited a series of Coal Sections under the microscope.

Mar. 21. Lecture by Mr. P. F. KENDALL, F.G.S., "Glacial Lakes and River Channels of Yorkshire," illustrated by a series of slides by Mr. GODFREY BINGLEY.

Apr. 18. Lecture by Mr. A. R. DWERRYHOUSE, "The New Red Series in England," illustrated by Specimens and lantern slides.

May 16. Lecture by Mr. WILLIAM CASH, F.G.S., "Notes on a Visit to Mexico," illustrated by lantern slides.

Besides these the Council calls special attention to the valuable record of the investigations of Mr. J. W. Bond in the Carboniferous Strata of Leeds.

The Council feel specially indebted to Mr. Parsons for the loan of his lantern, and his kindness in manipulating it on many occasions to the great advantage both of lecturer and members.

During the month of May the Council agreed to revive Field Meetings for practical work—in the evenings to places near Leeds, and on Saturdays to places more distant. Interesting evening excursions were made to Garforth and Meanwood, and were well attended.

The Transactions for the past two years will be in the hands of members at the beginning of next Session.

The Librarian reports that books, pamphlets, transactions of the Society, maps, etc., have now been rearranged, and a correct catalogue made out. He expresses the hope also that members will more largely avail themselves of the privilege.

PAPERS

READ BEFORE THE

Leeds Geological Association,

SESSION 1899-1900.

OCTOBER 25TH, 1899.

The opening meeting of the Association was held on the evening of Wednesday, 25th October, in one of the rooms of the Philosophical Hall—the new home of the Association.

According to time-honoured custom the early part of the evening was devoted to social intercourse among the members, tea and coffee having been provided by Mr. Bingley.

The Vice-President, Mr. P. F. Kendall, F.G.S., occupied the chair. After reading the minutes of the last meeting, Dr. Forsyth, the Hon. Secretary intimated to the Association that owing to pressure of business Mr. J. H. Howarth, F.G.S. had felt compelled to resign his position as President. On the motion of Mr. J. E. Bedford, F.G.S., Mr. Godfrey Bingley was unanimously elected President.

Mr. P. F. Kendall delivered a lecture on "Geology at the British Association," in which he pointed out the most important papers read, and the newest theories discussed at the September meeting. A lecture on this subject has been given by Mr. Kendall for several Sessions, and it has been productive of much good in directing the studies of members. He called special attention to the report of the investigations of Mr. W. Gibson, H.M. Geological Survey, regarding the relations of the upper Carboniferous rocks of North Staffordshire with the Red rocks of the Midlands; and the economic value of such careful surveys of our valuable ironstone and coal beds. The papers of Mr. R. Etheridge and Prof. Boyd Dawkins, on Coal Exploration in Kent, and on the Geology of the Channel Tunnel, were very interesting, but did not supply much new information. A very abstruse paper of great merit was read by Miss Ogilvie, on Sigmoidal Curves in the Earth's Crust, produced by rock-folds in two opposite directions, and causing "crust-torsion." A paper of more than local interest was read by Mr. Kendall on the relations of glacial lakes to post-morainic river drainage in Yorkshire; and also a report by him of the work done by the Committee appointed by the Association to make researches into the underground drainage of the Craven district in Yorkshire.

Mr. Bingley then exhibited a fine series of slides that he had made in a recent visit to "The Shakespeare Country;" Leamington, Kenilworth Castle, Warwick Castle and the gateways and old buildings of the town, Stratford, the Cathedrals of Gloucester and Worcester, Tewkesbury, and views on the Severn and Wye, which combined to give one of those artistic treats for which Mr. Bingley is so well known in this City and district.

DECEMBER 20TH, 1899.

"THE SOURCES OF THE RIVER AIRE,"

By Mr. J. H. HOWARTH, F.G.S.

Mr. Howarth described the historical and topographical aspects of the question.

From the valley of the Ribble by Stainforth, Capon Hall, and Malham Tarn, runs a long strip of Upper Silurian rocks which dies out under the Carboniferous limestone just eastwards of Upper Gordale. This strip is brought up by the North Craven fault, and its southern edge is sharply marked by the line of fault, and may be easily traced. On the north, this strip is bounded by the overlying Carboniferous limestone. Across by Neal's Ing and Cattrigg, the Silurian is nearly two miles wide, half-a-mile west of Capon Hall it narrows to zero, widens to about a mile at Malham Tarn, and narrows again eastwards to Gordale Beck.

All the rainfall and the springs on the limestone on the north of the Silurian sink into the limestone and are brought up to the surface again at the edge of the Silurian rocks, either in streams, or in Malham Tarn, only to sink again on reaching the limestone on the south side. Gordale Beck was thought to be an exception, but it has been proved now that Gordale stream is undergoing absorption. Some springs on the watershed between the Aire and Ribble—on the Aire side—appear on the northern edge of the Silurian, fed doubtless from the limestone above, and form the stream which on reaching the Craven fault disappears at the Smelt Mill. Other streams, on Grisedales and Antside, sink in potholes, and find their way by the same route as the Smelt Mill stream.

Malham Tarn is fed by springs from the limestone on the northern edge of the Silurian area. A small stream rises in the meadow of High Trenhouse, and some streams are at Water-Houses, and a small spring on the lake side. The Tarn rests on the upturned and denuded edges of the Silurian rocks, and is dammed in as to its sides with drift. The lake discharges at its south-east corner, and the outflow soon crosses the North Craven fault and sinks in the limestone.

Further east, under the escarpments about Middle House rise several streams which together form Gordale Beck.

There are thus three principal sinks—at the Smelt Mill, Malham Tarn Sinks, and in Gordale; while curiously enough there are three principal outlets—at Malham Cove, Airehead, and in Gordale bottom.

The earliest information points to the waters of Malham Tarn flowing down Comb Scar in floods and over the top of Malham Cove. Thomas Hartley in a pamphlet entitled "Natural Curiosities of the environs of Malham-in-Craven," refers to the stream at the foot of the cove; and of cascades from the top after rainy and tempestuous weather.

Rev. Thomas Dunham Whitaker, LLD., F.S.A., in his "History of Craven," published in 1805, speaks of cataracts precipitating themselves over rocks nearly 300 feet high, and meeting the collection of springs that rise after a subterranean course of more than two miles.

Mr William Howson in his "Guide to the District of Craven," published in 1850, speaks of the swollen waters making their way over the cove. From these remarks it is evident that as the joints in the limestone were widened by the solvent action of the water, they gradually absorbed the stream, and as this process continued the stream retreated; all floodwater no longer reaches Comb Scar.

Farmers and others had made attempts from time to time to ascertain the connections by inserting chaff at the sink, but without result. In 1879, Mr. Thomas Tate, of Leeds, made certain experiments, with the result that he concluded that Malham Cove, and the springs at Aire head were both connected with the Malham Tarn water-sinks; and that the Smelt Mill water-sinks were not connected with the Malham Cove (Y. Geo. & Poly. Soc., 1879). At the British Association, Professor Sylvanus Thompson, F.R.S. reported having introduced 1¼ pounds of Uranin, but without result. During the present summer (1899), the Yorkshire Geological and Poly. Society, through the generosity of Mr. George Bray, of Leeds, tried a series of exhaustive experiments.

Mr. Branson described the various chemical tests employed in the investigations—salt, ammonium sulphate, and fluorescein; and showed to the meeting the specimens obtained at various intervals, from various localities. These methods of investigation proved very interesting, and in some cases showed connections that had not been established before, for instance, the connection between the Smelt Mill Sink and Malham Cove, demonstrated both by salt and fluorescein. The number of analyses made—266 quantitative and 420 qualitative—showed the great amount of work done by the Committee.

JANUARY 17TH, 1900.

"THE DIVISIONS OF THE CRETACEOUS SERIES IN YORKSHIRE,"

By Mr. J. W. STATHER, F.G.S,

In the abscence of the President, the chair was taken by the Vice-President (Mr. P. F. Kendall, F.G.S.). Mr. J. W. Stather, F.G.S., President of the Hull Geological Society, read a paper on "The Divisions of the Cretaceous Series in Yorkshire."

Mr. Stather began by calling attention to the misleading statements of even the most recent text-books on the subject, and by stating clearly his objections to the classification of Yorkshire strata on the same lines as those of similar age in the South of England. Beginning at the base of the Cretaceous rocks, he noted in very full detail the interesting section of the Speeton clay beds, and summarised the main results of many investigators in this difficult and unique locality. Special reference was made to the work of Professor Judd, who, in an exhaustive paper read before the London Geological Society, said, "The section at Speeton Cliff is by far the most complete exposure of the Neocomian beds over the whole of the great North-European area;" and also to the more detailed labours of Mr. G. W. Lamplough on these beds both in Yorkshire and Lincolnshire. Professor Judd arranged these beds according to the occurrence in them of Ammonites; Mr. Lamplough discovered a surer key to the succession in the Belemnites. The lecturer showed by maps and sections the physical difficulties in the slipping down of the clay beds like "mud glaciers" to the beach, and pointed out in very full detail the various sub-divisions, with their characteristic fossil forms. After dwelling briefly on the extension of the beds at Knapton, Mr. Stather then described in less detail the more commonly known divisions of the Cretaceous rocks, red chalk, grey chalk, white chalk—noting such interesting points as the pink bands that cross the bedding, the variations in the occurrence and nature of the flints, and the difference between the condition in which fossils are found in the Micraster beds of Yorkshire and in those of the south.

The lecture was illustrated by a fine series of lantern slides, lent by Mr. Bingley, and illustrating the wonderful cliff scenery of the East Coast of the county.

FEBRUARY 21ST, 1900.

"BRITISH ASSOCIATION PHOTOGRAPHS"

By Mr. GODFREY BINGLEY.

After the transaction of the usual routine business Mr. Godfrey Bingley announced that he had obtained for the evening the loan of

the Geological Photographs of the British Association, and he hoped that these, supplemented by remarks of various members, would form the material for an interesting and instructive meeting. The photographs consisted (1) of microscopic slides showing the appearance of different rocks, such as breecia, conglomerate, Carboniferous limestone, Wenlock limestone, oolite; (2) showing the structure and appearance of rocks due to movements of the earth's crust, such as raised beach, submerged forest, faults, joints; (3) the effects of denudation, such as potholes, waterfalls, Brimham Rocks, Gaping Gill, Ingleborough, earthpillars, erratics, sea-stacks; (4) phenomena exhibited by igneous rocks, such as dykes, laccolites, agglomerate, Spindle Rock, St. Andrews; (5) exhibiting the origin of landscape, escarpment, pre-glacial valley, Trias-filled valley, Charnwood, Malham; (6) sections of rocks of different geological periods—Great Orme's Head, Filey Brig, Lulworth Cove, Squire's Hill, Antrim.

Messrs. Bedford, Bingley, Parsons, Whitmell, and Dr. Forsyth explained the geological features of such districts as they had personally visited. Mr. C. T. Whitmell, M.A., B.Sc., exhibited also a series of illustrative rock specimens from a number of the districts. Mr. J. W. Bond exhibited from the Leeds district some fine specimens of carboniferous fossils, in which the vegetable structure was very clearly shown.

MARCH 21ST, 1900.

"THE GLACIAL LAKES AND RIVER CHANNELS OF YORKSHIRE,"

BY MR. P. F. KENDALL, F.G.S.

Mr. Godfrey Bingley, the President, in a few words introduced Mr. P. F. Kendall, F.G.S., whose investigations into the geological and physical structure of the county are of more than local interest. Mr. Kendall then proceeded to deliver a lecture on "The Glacial Lakes and River Channels of Yorkshire," in which the main features were admirably illustrated by a series of slides by the President.

Mr. Kendall began his lecture by alluding to the great ice-sheet that occupied in the Glacial period the German Ocean, and that was fed by the glaciers from Norway, and from England and Scotland. The very existence of an ice-sheet has been questioned by Sir Henry Howarth and a few other geologists on the ground that an ice-sheet could not give sufficient impetus to spread ice over land. But, on the other hand, phenomena have been observed which are inexplicable, without bringing in the action of a great ice-sheet. An example of an obstructing glacier carrying down moraine material below the snow-line and obstructing streams is

some cases to determine whether it is the upper or lower limestone which occurs in a given section. In the quarries at Knaresborough, and in the gorge of the River Wharfe at Boston Spa, the beds appear contorted, but Mr. Dwerryhouse thinks this apparent contortion is due, not to any actual folding or crumpling of the beds, but rather to irregular solution of the rock by percolating waters, and a consequent irregular subsidence of the beds. The outcrop of the magnesian limestone forms a considerable escarpment throughout the whole of its length from Durham to Nottingham, and overlooks the lower lying land occupied by the Upper Carboniferous rocks.

To the west of the Pennine Chain the series is very different, and in the neighbourhood of Carlisle the section is:—

8, Stanwix marls (100ft.);
7, Sandstone (500ft.);
6, Gypsiferous shales (700ft.);
5, St. Bees sandstone (1,500ft.);
4, Magnesian limestone (calcareous shales);
3, Hilton plant beds;
2, Penrith sandstone, with Upper Brockram;
1, Lower Brockram. Permian.

The Lower Brockram is a coarse conglomerate, consisting of sub-angular masses of Carboniferous limestone and jaspery chert, enclosed in a matrix of Red sandstone. The blocks vary in size from mere pebbles to masses three or four feet in length. The Lower Brockram is well exposed in the natural section at Hoff, about a mile from Appleby, and also in the bed of the River Eden at Stenkrith, near Kirkby Stephen. The Penrith sandstone is of a bright red colour, due to the cementing ferruginous material; and many of the grains of sand show secondary crystallization. The plant remains are found in flaggy micaceous sandstones and thin beds of reddish shale. The Gypseous shales are thin beds of shale containing considerable quantities of gypsum, and are immediately overlaid by the Kirklinton sandstone, highly-coloured rocks, red, yellow, and white predominating.

In the southern portion of Lancashire and the lowlands of Cheshire the series is considerably changed; and in the Midland Counties the Keuper marls are marked by the rich rock-salt deposits of Northwich and Droitwich. In some districts in the counties of Leicester and Warwick the Bunter entirely disappears, and the Keuper rests unconformably on the older rocks. Of fossil organisms found in these beds the most common are foraminifera, corals, brachiopoda (of Carboniferous genera), the last of the trilolites, so characteristic of the older formations, and a few plant remains, also of Carboniferous types. The types of animal life seem to point to similar conditions as the Caspian area; and the presence of such deposits as gypsum and rock salt indicate also the gradual evaporation of sea water. The evidence is very strongly in favour of the

new red rocks of Britain having been deposited in an area in which, during at least part of the time, desert conditions prevailed. A good deal of discussion has taken place as to the junction of the Permian and Trias rocks. Many geologists argue that the junction is unconformable, but more full investigation, especially of the Stockport sections, by Mr. Kendall, proves that there has been no stratigraphical break.

Mr. Dwerryhouse concluded his lecture by urging upon the members the need for investigation of a district so near to Leeds, and, notwithstanding its poverty of fossils, so interesting on many other points. The lecture was illustrated by maps, diagrams, fossil and rock specimens, and a fine series of lantern slides.

MAY 16TH, 1900.

"NOTES ON A VISIT TO MEXICO,"

BY MR. WILLIAM CASH, F.G.S.

After the usual routine business, the President, Mr. Bingley, briefly introduced the lecturer of the evening, Mr. William Cash, F.G.S., who proceeded to give a lecture on "Notes on a Visit to Mexico."

Mr. Cash sketched first the physical configuration of the country. The coast belt and the terraces up to 3,000 feet are called the tierras calientes, in which tropical vegetation flourishes, and yellow fever prevails. The immense table land, which occupies the interior, constitutes the tierras frias, or cold lands, and the climate is almost that of perpetual spring. An immense desert extends towards the north of the plateau. The mountains run in long ridges from north to south, but numerous cross ridges and volcanic peaks break the surface of the country into minor table lands. The rivers are of little use for navigation, as they are usually interrupted by waterfalls. Although the country is favoured by climate, agriculture has been much neglected till recent years, but now irrigation and improved methods are leading to increased production. From the times of the Spanish Conquest mining has been the important industry. Silver, copper, iron, quicksilver, and many other minerals are found. The native Indians—remnants of the ancient Aztecs—constitute over one-third of the population. They live in a very primitive fashion, and are remarkable for their skill in pottery and embroidery. The remains of ancient pyramids, temples, and rock sculptures indicate the existence of a high civilisation before the advent of the Spaniards.

By the help of a fine series of slides, Mr. Cash showed the nature of the vegetation, and of the scenery of the land, and the occupations of the natives. It was very interesting to see tramways, electric wires, and gorgeous cathedrals associated with the remains

of an old-world civilization. In concluding his remarks, Mr. Cash pointed out the great progress that the country was making in order and government, and in the development of railways and of the natural resources.

RECORDS OF THE INVESTIGATIONS OF MR. J. W. BOND IN THE CARBONIFEROUS STRATA OF THE LEEDS DISTRICT.

In recording my work in the Carboniferous strata in the Leeds District, I have thought it advisable to start at the seat-earth of the Better Bed Coal (the well-known bed of fireclay for which the Leeds district is noted, and the first workable seam of coal above the Elland flagstone), and from this point to take the different seams as they rise until we reach the Blue Bind, above the Beeston Bed Coal, detailing the nature of the different strata in consecutive order, enumerating the fossils to be found in each seam, and showing where each of these seams may be examined by the light of day in the quarries of the brickworks in the district.

The quarries of the brickworks which I have visited are:—

THE LEEDS PATENT BRICK CO., Benson Street and Dolly Lane.

MR. HARRISON, Brickworks, Stoney Rock Road.

THE ROCK RED BRICK CO., Stoney Rock Road.

MESSRS. T. & J. MOODY, Brickworks, York Road.

Clarke Lane, Leeds.

THE LEEDS PATENT BRICK CO.'S QUARRY, BENSON STREET, LEEDS.

In all Sections the beds are arranged in ascending order.

	ft.	in.
In this quarry we meet with the outcrop of the Fireclay and Better Bed Coal.		
1. The seat-earth or Fireclay average in thickness	3	0
I have found only one fossil in this seam, as in all other seat-earths, that is the Stigmaria ficoides, the seam is full of them.		
2. Better Bed Coal, average	1	6
This seam gives better impressions of plants than any other in the district, and also is very good to cut for microscopic sections which show the Macrospores and Microspores in many forms. List of fossils found:—		

Sigillaria,	semipulvinata,	Kidston,
ditto.	discophora,	Konig sp,
ditto.	reniformis,	Brongt,
ditto.	alternans,	,,
ditto.	micandi,	Zeiller,
Calamitina,	varians,	Sternb sp,
Carpolithus,	ellipticus,	Sternb,
Sigillaria,	polyploca,	Bowlay

THE LEEDS PATENT BRICK Co.'s QUARRY,

DOLLY LANE, LEEDS.

The base of this quarry commences with:—

		ft.	in.
1.	Blue Bind with Ironstone Nodules	8	0
2.	Seat earth (with stigmaria)	1	6
3.	Thin bed of coal	0	9
4.	Black Shale	1	6
	This seam of coal forms a basin in the quarry, dipping to a centre at an angle of about 5 deg., the black shale taking the same line as the coal; there are a few fish remains to be found in the black shale.		
5.	Blue Shale	4	0
6.	Band of Ironstone Nodules...	0	6
	There are a few Anthracosia to be found in the Nodules.		
7.	Blue Bind with Ironstone Nodules	29	0
	It is in these Nodules that the best of the fossils are to be found. List of fossils found:—		

Lepidostrobus	containing	Macrospores,
ditto.	ditto.	Microspores,
Calamitina,	varians,	Sternb sp,
ditto.	varians,	var insignis, Weiss,
Stylocalamites.	Suckovii,	Brongt sp,
Eucalamites,	ramosus,	Artis sp,
Calamocladus,	equisetiformis,	Schlotheim,
Sphenopteris,	adiantoides,	Lindley & Hutton,
ditto.	cf herbacea,	Bowlay,
Renaultia,	Footneri,	Marrat sp,
Mariopteris,	muricata,	Schl sp,
Alethopteris,	lonchitica,	Schl sp,
Neuropteris,	heterophylla,	Brongt sp,
ditto.	obliqua,	Brongt,
Lepidodendron,	ophiurum,	Brongt,
ditto.	obovatum,	Sternb,
Lepidostrobus,	variabilis,	L & H,
Carpolithus,	ellipticus,	Sternb,
Trigonocarpus,	Parkinsonii,	Brongt,
Artisia,	approximata,	Brongt.

8.	Brown soft sandstone	3	0

	ft.	in.
9. Brown Bind	25	0
10. Sandstone	2	0
11. Seat earth (stigmaria)	3	0
12. Black Bed Coal	1	6
13. Yellow surface clay and soil	1	6

This section is taken through the outlier of the Black Bed Coal as shown on sheet 93 of the Geological Survey, Dolly Lane, Leeds.

AN ADDITIONAL LIST.

Sphenopteris,	obtusifolia,	Brongt,
ditto.	furcata,	Brongt,
Bothrodendron,	minutifolium,	Artis sp,
Lepidodendron,	Wortheni,	Lesqx,
Calamites,	Cestii,	Brongt,
Dactylotheca,	plumosa,	Artis sp,
Lepidodendron,	aculeatum,	Sternb.

MR. HARRISON'S QUARRY,

STONEY ROCK ROAD, LEEDS.

This quarry is situated on the east-side of the Burmantofts Cemetery, and on the outcrop of the Crow Coal; this is the third workable seam above the Elland Flagstone. There is a portion of the strata I shall have to omit betwixt the Black Bed Coal and the Crow Coal, as there is no artificial opening from which to collect specimens, to measure the strata. The base of this quarry is about 12ft. 6in. below the Crow Coal.

1. Bed of sandstone	3	0
2. Strong Shale	0	6
3. Bed of sandstone	1	6
4. Black Shale with very large Ironstone Nodules	6	0

The greater portion of this seam is one mass of impressions of plants. List of specimens found:—

Stigmaria,	ficoides,	
Mariopteris,	muricata,	Schl sp.
Alethopteris,	lonchitica,	ditto.
Sigillaria,	discophora,	König sp,
ditto.	tessellata,	Brongt,
Trigonocarpum,	Parkinsonii,	Brongt,
Lepidodendron,	obovatum,	Sternb,
Pinnularia (rootlets).		

5. Small seam of coal	0	6

This coal is called by miners "doddies," and is a very inferior coal.

		ft.	in.
6.	Bed of Blue Shale or Clay (with stigmaria)	1	0
	Lepidodendron, aculeatum, Sternb.		
7.	Crow Coal	1	6
	This is a very bright and clean coal and very much used for household use; I have found no impression of plants.		
8.	Blue Shale	1	6
9.	Blue Bind	18	0
	In this bind there are many layers of Ironstone Nodules; it is in these nodules that the fossils are to be found, perfect specimens of Lepidostrobus, and also the Lepidostrobus attached to the Lepidodendron. In many of these specimens there are the Microspores found.		
	Calamites, suckovii, Brongt,		
	Calamocladus, equisetiformis, Schl sp,		
	Neuropteris, heterophylla, Brongt,		
	Lepidodendron, obovatum, Sternb,		
	Annularia, radiata, Brongt.		
10.	Thin bed of blue clay	0	10
11.	Yellow	3	0
12.	Soil	3	0

ROCK RED BRICKWORKS,

STONEY ROCK ROAD, LEEDS.

This is a new opening to the south-east of Mr. Harrison's quarry, it is higher in the series.

Commencing at the base of this quarry we find a

1.	Blue Stone ... ... 1' 6" to	2	0
	I do not know whether it is Carbonate of Iron or Carbonate of Lime, but I will submit a specimen. It occurs in irregular blocks, some rounded and some angular. For Analysis of specimen see Note 1.		
2.	Blue Bind with Ironstone Nodules	7	0
	Fossils found in Ironstone Nodules:—		
	Stylocalamites, suckovii, Brongt sp,		
	Mariopteris, muricata, Schl sp,		
	Sphenopteris sp.		
3.	Fine sandstone	0	5
4.	Blue Bind	6	4
5.	Fine sandstone with stigmaria	1	0
5.	Black Shale	7	9
7.	Yellow clay and surface soil	4	3
	All these seams outcrop here; the uniform dip is about 5deg, S. S.E., the dip is about equal in all these quarries.		

MESSRS. T. & J. MOODY'S QUARRY,

YORK ROAD, LEEDS.

This quarry is situated about half-a-mile south of the Rock Red Brick Co.'s quarry, and is higher up in the series, although the base of this quarry is slightly lower than the above, and nearer in depth to the Crow Coal.

		ft.	in.
1.	Blue Stony Bind	5	0
2.	Seat earth	4	0
	This seat earth ranks next to the Better Bed seat earth for fireclay quality. It burns very hard and is of stone colour when burnt, and it is full of roots and rootlets (Stigmaria ficoides).		
3.	Coal	0	4
4.	Black Shale	1	0
5.	Blue Bind	8	0
6.	No. 1. Blue Stone, as in Rock Red Brick Co. ...	1	6
	For Analysis of specimen, see below in Note 2.		
7.	Blue Bind	12	0
8.	No. 2. Blue Stone, as above (for Analysis see Note 3)	1	0
9.	Grey Bind	3	0
10.	Fine grey sandstone, with ripple marks	0	8
11.	Grey Bind	3	0
	In this seam there are fine specimens of Stigmaria ficoides; some measuring 8ft. in length.		
12.	Blue Stony Bind	3	0
	In this seam we find the Stylocalamites, suckowii, Brongt sp, also Artisa approximata.		
13.	Seat earth (with stigmaria)	2	0
14.	Coal	0	1
15.	Black Shale	6	0

SPECIMENS from above BEESTON BED COAL,

At the opening of MARSH LANE TUNNEL & CLARK LANE QUARRIES.

Sphenopteris,	acuta,	Brongt,
ditto.	multifida,	L & H,
ditto.	furcata,	Brongt,
Renaultia,	Footneri,	Marrat sp,
Calamocladus,	equisetiformis,	Schl sp,
Dactylotheca,	plumosa,	Artis sp,
Mariopteris,	muricata,	Schl sp,
Alethopteris,	lonchitica,	ditto.
ditto.	valida,	Boulay,
Neuropteris,	heterophylla,	Brongt,
ditto.	tenuifolia,	Schl sp,
Sphenophyllum,	cuneifolium,	Sternb sp,

Lepidophloios,	acerosus,	L & H,
Palæostachya,	pedunculata,	Williamson,
Trigonocarpum,	parkinsonii,	Brongt,
Sphenopteris,	obtusiloba,	ditto.

Cyclopteroid pinnule of Neuropteris heterophylla, Brongt.

These specimens are all taken from the Blue Bind, above the Beeston Bed Coal in the above openings, but I have been prevented by illness from measuring up the strata.

NOTES :—

The Analyses of rock specimens were made by Messrs. F. A. PENN, Assoc., R.C.S. and J. LISTER, Assoc., R.C.S., Leeds Higher Grade School, Chemical Department.

	Specimen 1.	Specimen 2.	Specimen 3.
S_1O_2	31.2	39.3	36.3
Fe_2O_3 }	18.17	9.9	10.1
Al_2O_3 }		21.7	15.1
Ca O	22.99	10.0	17.2
Mg C	5.14	3.9	5.2
CO_2	20.7	14.9	15.7
H_2O	1.1		
	99.4	99.7	99.8

LEEDS GEOLOGICAL ASSOCIATION.

The Annual Meeting of the Leeds Geological Association was held in the Library of the Philosophical Hall, on the evening of the 13th June, the President, Mr. Godfrey Bingley, in the chair.

The Reports for the Session were read by the Secretary, Treasurer, and Librarian, and approved by the meeting for insertion in the Transactions.

The officials were appointed for next Session:—

President: Mr. GODFREY BINGLEY.

Vice-President: P. F. KENDALL, F.G.S.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretaries: DAVID FORSYTH, M.A., D.Sc., AND WALTER PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council: JAMES E. BEDFORD, F.G.S., J. H. HOWARTH, F.G.S., JOHN W. BOND, A. R. DWERRYHOUSE, B.Sc., C. D HARDCASTLE, E. HAWKSWORTH, B. HOLGATE, JOHN INGLEBY, REUBEN NUNNS, C. T. WHITMELL, M.A., B.Sc.

LEEDS GEOLOGICAL ASSOCIATION.

BALANCE SHEET, JUNE 30TH, 1900.

Receipts.

		£	s.	d.
July 1st, 1899	To Cash in hand ...	7	16	3
June 30th, 1900	,, Subscriptions received	14	10	0
	,, ,, in advance	0	17	6
	,, Sale of Transactions	0	4	0
		£23	7	9

Expenditure.

		£	s.	d.
Oct. 22nd, 1899	By Librarian's Expenses ...	0	14	5
Dec. 30th, 1899	,, Loan of Lantern (Y.R.C.)... ...	0	5	0
Feb. 23rd, 1900	,, Carriage of B.A. Slides	0	6	6
June 13th, 1900	,, R. Crosland ...	2	7	11
June 30th, 1900	,, Rent of Room ...	5	0	0
	,, Caretaker	0	5	0
	,, Reynolds and Branson's Account	0	12	2
	,, Secretary's Expenses	2	15	1
	,, Treasurer's ,,	0	6	0
	,, Balance	10	15	8
		£23	7	9

S. W. CUTTRISS, *Hon. Treasurer.*

LIBRARY

OF

The Leeds Geological Association.

ADDITIONS SINCE THE ISSUE OF THE LAST TRANSACTIONS.

BOOKS.

Smithsonian Reports for 1896.
Do. 1897.
United States Geological Survey:—
Geology of the Aspen District, Colorado.
Do. Old Hampshire County, Massachussets.
Do. Yellowstone National Park.
Do. Narraganselt Basin.
Glacial Gravels of Plaine, and their associated deposits.
The Crystal Falls Ironbearing District of Michigan.
Fossil Flora of the Lower Coal Measures of Missouri.
The Illimois Glacial Lobe.
18th Annual Report, 1896-97:—
Part II., Papers chiefly of a theoretic nature.
Part III., Economic Geology.
Part IV., Hydrography.
Part V., Metallic Products and Coal.
Part V cont., Non-metallic Products, except Coal.
19th Annual Report, 1897-98:—
Part III., Economic Geology.
Part IV., Hydrography.
Part V., Forest Reserves.
Part VI., Metallic Products, and Coal and Coke.
Part VI. cont., Non-metallic Products, except Coal and Coke.
20th Annual Report, 1898-99:—
Part VI., Mineral resources of the United States.
Metallic Products, Coal, and Coke.
Part VI. cont., Non-metallic Products, except Coal and Coke.

PAMPHLETS.

The Origin and History of varieties of Agates, Flint, and other silicious Nodules, by C. D. Hardcastle.
Earth-crust Movements and their causes, by Joseph Le Conte.

The Mechanical Composition of Wind Deposits, byJohan August Udden.
The Age of the Earth as an abode fitted for life, by Lord Kelvin.
Crater Lake, Oregon, by J. S. Diller.
Rising of the land arouud Hudson Bay, by Robert Bell.
The Copper-mining Industry, and the distribution of Copper Ores in New South Wales.
1896 Taylor, C. H., 12, Springfield Mount, Leeds.

TRANSACTIONS.

Proceedings of the Geologists' Association.
Do. Yorkshire Geological and Polytechnic Society.
Transactions of the Leeds Geological Association, Part XI., 1896-7-8.
Do. Manchester Geological Society.
Memoirs and Proceedings of the Manchester Literary and Philosophical Society.
Journals of the Manchester Geographical Society.
Transactions of the Hull Scientific and Field Naturalists' Club.
The Scientific Transactions of the Royal Dublin Society.
Records of the Geological Survey of New South Wales, (1898 and 1899).
Annual Report of the Department of Mines and Agriculture, New South Wales (1897 and 1898).
Records of the Australian Museum.
Report on the Wyalong Gold Field, by J. H. Watt, M.A., B.Sc.
Transactions of the Connecticut Academy of Arts and Sciences.
Do. Wisconsin Academy of Science, Arts, and Letters.
Annals of the Natural Museum of Buenos Ayres.
Transactions of the Australasian Institute of Mining Engineers.
Bulletin of U.S.A. Geological Survey, Nos. 150-162.
Rock Specimens with Photographs.
Index of Carboniferous Invertebrates of Tertiary Plants.
Gneisses and Gabbros of S.W. Minnesota.
Moraines of S. Dakota
Lower Cretaceous Gryphaeas of Texas.
Bibliography of Geology, etc., for 1898.
Dictionary of Altitudes.

MAPS, &c.

British Geological Photographs, by W. W. Watts, M.A., F.G.S.
United States Geological Survey—Atlas to accompany Geology of the Aspen District Colorado.

Honorary Members.

*Those who have contributed Papers or conducted Excursions are distinguished by an asterisk **

Year of Election.

1887 *Chadwick, Saml., F.G.S., New Zealand.
1886 *Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, near York.
1893 *Hardcastle, C. D., 31, Victoria Place, Camp Road, Leeds (*Member of Council*)
1886 *Horne. Wm., F.G.S., Leyburn.
1891 *Marr, J. E., M.A., F.R.S., Sec. G.S., St. John's College, Cambridge.
1874 *Miall, Professor, L. C., F.R.S., F.G.S., F.L.S., 8, Spring Road, Headingley.
1887 *Sollas, Professor W. J., D.Sc., F.G.S., Oxford.
1887 *Spencer, Jas., 8, Salisbury Place, Akroydon, Halifax.
1890 *Woodward, A. S., F.G.S., F.Z.S., Natural History Museum, S. Kensington.
1896 *Groom, Professor T. T., M.A., D.Sc. Royal Agricultural College, Cirencester.

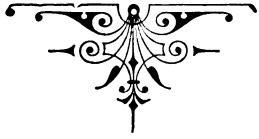
Members

1874 *Allbutt, H. A., 24, Park Square, Leeds.
1885 Asquith, W. E., 23, Cardigan Road, Leeds.
1891 Bailey, John Wm., 2, St. Mark's Villas, Leeds.
1897 Bain, John, The Bracken, Ilkley.
1899 Barnett, R. E., B.Sc., The Leeds Technical School, Cookridge Street, Leeds.
1888 Bedford, James, Sycamore Lodge, Woodhouse Cliff, Leeds.
1882 *Bedford, J. E., F.G.S., Shire Oak Road, Headingley (*Member of Council*).
1895 Bees, W. J., School Board Offices, Leeds.
1889 *Bingley, Godfrey, Thorniehurst, Shaw Lane, Headingley, Leeds (*President*).
1896 Bond, Robert, 59, Stoney Rock Road, Burmantofts, Leeds.
1883 Branson, F. W., F.C.S., 14, Commercial Street, Leeds.
1889 Bricknell, F. W., A.M.I.C.E., Town Hall, Hull.
1883 *Brownridge, Chas., F.G.S., A.M.I.C.E., 26, North Road, Birkinhead.
1889 *Carter, Rev. Wm. Lower, M.A., F.G.S., Hopton, Mirfield.
1891 *Clough, S., Micklefield.
1886 Crosland, Richard, 69, Woodhouse Lane, Leeds.
1886 Crowther, J. A., Borough Engineer, Bootle, Liverpool.
1890 *Cuttriss, Saml. W., Prudential Buildings, Park Row, Leeds (*Hon. Treasurer*)
1896 Dodgson, Aquila, Southleigh, Kirkstall Lane, Headingley.
1896 Dwerryhouse, A. R., B.Sc., F.G.S., 5, Oakfield Terrace, Headingley (*Member of Council*).
1887 Ellis, Edward, M.I.C.E., Springfield House, Bramley.
1891 *Forsyth, David, M.A., D.Sc. 2, Lifton Place, Leeds (*Hon. Secretary*).
1893 Forsyth, John A. Cairns, M.Sc., 2, Lifton Place, Leeds.
1892 Hanbury, Chas., 1, Park Place, Leeds.

1886 *Hawkesworth, Edwin, 11, Nursery Mount, Hunslet *(Member of Council)*.
1890 Heaton, Henry, 53, Roundhay Road, Leeds.
1887 Hewson, Thos., M.I.C.E., City Engineer, Leeds.
1889 Hewson, Thos., Junr., Park Cottages, Roundhay.
1885 Hill, John, J.P. Colliery Offices, Morley.
1875 *Holgate, Benjn., F.G.S., The Briers, North Park Avenue, Roundhay, Leeds (*Member of Council*).
1896 Holmes, G., 16, Ridgeway Terrace, Delph Lane, Leeds.
1889 *Howarth, J. H., F.G.S., Stoneygate, Savile Park, Halifax *(Member of Council)*
1887 *Ingleby, John, 12, Bainbrigge Road, Headingley (*Member of Council*).
1886 Kay, Stanley R., 20, Grange Avenue, Leeds.
1891 *Kendall, P. F., F.G.S., 5, Woodland Terr., Chapel-Allerton (*Vice-President*).
1893 Kendall, Mrs. P. F., do. do.
1893 Kirk, Albert, Buckingham Villas, Headingley.
1893 *Lang, Joseph, 64, Samuel Street, Camp Road, Leeds (*Hon. Librarian*).
1900 Lupton, Arnold. 6, De Grey Road, Leeds.
1889 Mitchell, Fred, 9, Upper Fountain Street, Leeds.
1900 Moore, Rev. H. H., St. John's Vicarage, Darwen.
1884 Nettleton, Hugh, Borough Engineer, Weston-Super-Mare.
1885 Nunns, Reuben, 41, Whitehouse Street, Hunslet (*Member of Council*).
1895 *Parsons, W., F.R.G.S., School Board Offices, Leeds (*Hon. Secretary*).
1892 Pawson, Albert H., Lawns House, Farnley.
1874 *Pocklington, H., F.R.M.S., 41, Virginia Road, Leeds.
1897 Pocklington, William E., 41, Virginia Road, Leeds.
1885 *Redmayne, John, Grove House, Headingley.
1896 Riley, A., Linburn, Grove Road, Harrogate.
1885 Ripon, The Most Hon. The Marquis of, K.G., Studley Royal, near Ripon.
1871 Roebuck, W. D., F.L.S., 259, Hyde Park Road, Leeds.
1887 *Rowley, Walter, M.I.C.E., F.G.S., Alder Hill, Meanwood.
1887 Stephenson, John, Browaberrie Manor, Horsforth.
1890 Stephenson, W. E., do. do.
1892 Teasdale, Washington, F.R.M.S., 255, Hyde Park Road, Leeds.
1897 Townsend, H. G., Myrtle Cottage, Altofts, Normanton.
1897 *Whitmell, C. T., M.A., B.Sc., Invermay, Victoria Road, Headingley, Leeds (*Member of Council*).
1889 Wilkinson, J. J., Burnside, Skipton.
1891 Witts, J. W., Borough Engineer's Office, Leeds.

Associates.

1894 Bond, John Wm., Torre Road, Burmantofts, Leeds (*Member of Council*).
1896 Ogilvie, Thos. W., 21 Providence Avenue, Delph Lane, Leeds.



Science Library
QE
1
.L48
v.3
pt.13

Transactions

OF THE

Leeds Geological Association.

PART XIII.

1900-1.	1903-4.
1901-2.	1904-5.
1902-3.	

PRICE:—ONE SHILLING & SIXPENCE.

(*Members may purchase extra copies at One Shilling each.*)

UNIVERSITY OF MICHIGAN LIBRARIES

THE

TRANSACTIONS

OF THE

LEEDS

Geological Association.

PART XIII.

1900-1.	1903-4.
1901-2.	1904-5.
1902-3.	

EDITED BY

E. J. EDWARDS, M.Sc., and E. HAWKESWORTH,

Hon. Secretaries.

LEEDS:

JOWETT & SOWRY, Printers, 30, Park Row.

1906.

Science Library
QE
1
.L48
v.3
pt.13

CONTENTS.

	Page.
Preface	4
Report, 1900-1901	5
The Airedale Glacier—Muff	6-7
Geology of Ingleborough—Howarth	7-13
References to other Papers, 1900-1901	12
Report, 1901-1902	14-15
Aims of a Local Geological Society—Forsyth	15-17
References to other Papers, 1901-1902	17
Report, 1902-1903	18-19
Causes of Volcanic Action—Forsyth	19-21
Geological Photography—Bingley	22-23
Underground Waters of Ingleborough—Dwerryhouse	23
Glacier Lakes in Cleveland Hills—Kendall	23-24
Report, 1903-1904	25-26
Geology and Vegetation of West Riding—Smith	26-29
Origin of British Fauna and Flora—Kendall	29-31
References to other Papers, 1903-1904	32
Report, 1904-1905	33-34
Some Drift Deposits near Leeds - Hawkesworth	34-39
River Capture in Yorkshire—Carter	40-41
Eastern Extension of Yorkshire Coalfield—Kendall	41-44
References to other Papers, 1904-1905	45
Report of Magnesian Limestone Committee—Dwerryhouse ...	45-48
List of Members	49-51
Officers, 1906-1907	52

PREFACE.

In submitting this volume of Transactions it is necessary to explain that owing to lack of funds it has been impossible to issue one earlier; so that in order to bring the work up to the end of the 1904-5 session, the matter has had to be compressed severely. Abstracts of only such Papers as relate to Yorkshire, and a few of general interest, are included, but it is hoped the references added to these, and to the subjects of other lectures, will add to the utility of the volume.

The Abstracts have been approved by the authors, who alone are responsible for the facts and opinions contained in their respective Papers.

A. R. DWERRYHOUSE, D.Sc., F.G.S., *President.*

E. J. EDWARDS, M.Sc., } *Hon. Secs.*
E. HAWKESWORTH, }

DAVID FORSYTH, M.A., D.Sc.

} *Transactions Sub-Committee*

TWENTY-SEVENTH SESSION, 1900-1901.

Officers:

President: GODFREY BINGLEY.

Vice-President: P. F. KENDALL, F.G.S.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretaries: DAVID FORSYTH, M.A., D.Sc. / WALTER PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council:

J. E. BEDFORD, F.G.S.,
JNO. W. BOND.
A. R. DWERRYHOUSE, B.Sc., F.G.S.
C. D. HARDCASTLE.
E. HAWKESWORTH.
B. HOLGATE, F.G.S.
J. H. HOWARTH, F.G.S.
JNO. INGLEBY.
R. NUNNS.
C. T. WHITMELL, M.A., B.Sc.

The following Meetings were held:—

1900.

Oct. 12—SPECIAL PUBLIC MEETING in the Philosophical Hall, to which members of other local Scientific Societies were invited.

Lecture by JAMES STIRLING, *President of the Geological Society of Australasia, and Government Geologist of Victoria,* on "The Geology of Victoria as applied to Mining." (*Lantern illustrations.*)

Oct. 24—Opening Meeting of the Session (at the Yorkshire College), President's Address—

"The Geology of North Wales." P. F. KENDALL, F.G.S. (*Lantern illustrations by the President.*)

Inspection of the Geological Laboratory.

Nov. 21—"Geology at the British Association." DAVID FORSYTH, M.A., D.Sc.

Dec. 19—"The Airedale Glacier." HERBERT B. MUFF. (*Illustrated by maps and sections.*)

1901.

Jan. 16—"A Trip to the South of France and Coast of Italy." J. E. BEDFORD, F.G.S.

"Notes on some Geological Excursions." E. HAWKESWORTH. Exhibition of specimens.

Mar. 20—"The Geology of the Cheviots." P. F. KENDALL, F.G.S. (*Illustrated by specimens, and a series of slides by the President.*)

April 17—"The Geology of Ingleborough." J. H. HOWARTH, F.G.S. (*Illustrated by maps, sections, and lantern slides.*)

May 15—"The Magnesian Limestone." A. R. DWERRYHOUSE, B.Sc.

June 19—ANNUAL BUSINESS MEETING.

"THE AIREDALE GLACIER."

Abstract of Paper read by Mr. H. B. MUFF, B.A., F.G.S., *December 19th*, 1900.

The general trend of the Aire valley is from N.W. to S.E., and it receives important tributaries from the south side, such as the Glusburn, Worth, Harden, and Bradford becks. Those from the northern side are much smaller. The larger tributary valleys are excavated in the plateau of Upper Carboniferous rocks.

Boulder Clay is found in many parts of Airedale. It consists of a tough blue clay, with a surface covering of yellow sandy clay of very variable thickness. The included stones are mostly Carboniferous limestones, cherts, grits, and sandstones, with shales and ironstone nodules. As would be expected, the limestone boulders become less in number and size the further they are found down the main valley. Most of the boulders in the blue clay are beautifully moulded and striated. Gravel is found often above and at the margin of the Boulder Clay, and in some places is current-bedded. Striæ are found frequently on beds of Millstone Grit, when they have a covering of clay, and, in such cases, not only are the striæ visible on the general surface, but also on the larger included quartz pebbles at the surface.

Evidences of the maximum extension of the glacier in the main and tributary valleys are abundant. The floor of the Glusburn valley is covered with Boulder Clay. On Cowling Moor, a long ridge of unstratified gravel, 50 feet thick, is found at a height of 1,150 feet. Great masses of a hard conglomerate of limestone, grit, and shale occur, the cementing material being calcite, evidently deposited from solution by percolating water. Above this a ridge of sandy clay, containing limestones, cherts, and grits, may be traced under the peat up to 1,350 feet, and even to a higher point to the westward. Combe Hill (1,454 feet) was not over-run by the ice, as its surface is covered with angular fragments of the underlying grits, and there is a complete absence of drift from its southern slopes. Probably it was a "nunatak" in glacial times. Traced eastwards, the altitude of the margin of the drift diminishes all the way down Airedale. On Keighley Moor it reaches 1,250 feet; in the Worth Valley, above Ponden, 950 feet; and on Haworth Moor, above Leeshaw reservoir, 1,025 feet. In Harden Valley a marginal moraine is seen at Hallas Rough Park, at a height of 900 feet. Thick deposits of clay can also be traced in the Bradford Valley, and Boulder Clay is found on the top of Stonehall Hill, Eccleshill, at an altitude of 700 feet. The altitude diminishes at Newlay to 200 feet, where a mass of gravel, 30 feet thick, occurs.

From similar evidence it is concluded that a glacier traversed the Wharfe Valley, and became confluent with the Airedale one by Guiseley, Yeadon, and Horsforth, while the summit of Rombald's

Moor was uncovered, as another "nunatak." The morainic remains from Apperley Bridge upwards, as at Tong Park, Esholt; Nab Wood, near Saltaire; and at Bingley, are evidences of a retreating glacier.

Filling the main valley, the glacier would dam back the drainage of the lateral valleys, and in these embayments temporary lakes would be formed. The level of these lakes was determined by the height of the ice-barrier, and of the watershed round the lake. An overflow of the waters of such a lake occurred at the lowest point of the margin, into the succeeding lower lake. This action accounts for the numerous instances of spur-cutting valleys which make the ridges dividing tributary valleys appear to be notched. The very temporary nature of the surface level of these lakes is proved by the evident rapidity with which the gorges seem to have been cut, and by the absence of beaches along the margins of the areas once covered by lakes.

Deltas have, however, been found, their surfaces corresponding in altitude with the outlets from the lake in which they occurred.

REFERENCE :—"The Glaciation of the Bradford and Keighley District," by A. JOWETT, M.Sc., and H. B. MUFF, B.A., F.G.S. (with maps and illustrations), Proc. Yorks. Geol. and Polyt. Soc., vol. xv., part 2, 1904.

"THE GEOLOGY OF INGLEBOROUGH."

Abstract of Paper read by Mr. J. H. HOWARTH, F.G.S., *April 17th*, 1901.

The structure of Ingleborough and its neighbouring hills reminds us of the old sponge-cakes of our boyhood—consisting of layers of spongy substance and layers of jam. Imagine such a cake with six layers of jam in it, each layer overlaid with cake, and the top and bottom baked to a nice brown crust. This homely illustration is a representation of the structure of nearly all the mountains of the district, and especially of Ingleborough itself. The jams represent the limestones, the sponge layers the grits and shales, the brown top crust indicates the Millstone Grit, and the bottom one the Silurians, upon which all the layers are piled. This simple illustration has another aspect. A V-shaped piece cut out of the cake would show all the layers in section. If cuts were made to varying depths, or in irregular ways, the result would still be the exposure of some layers and their relation to each other, and a comparison of such cuts would make it possible to see the structure of the whole mass. Denudation has chiselled out such gaps in this mountain region, and the patient piecing together of the sections exposed has enabled us fairly to understand the structure of the whole district. The scenery of the denuded country indicates something of its structure, the limestones cropping out and forming prominent profiles, and the shales weathering into the gentler slopes

of the fells and moors. This simple explanation does not, however, apply to all points, when details come to be carefully examined. Faulting comes in and dislocates levels, and sometimes, owing to non-deposition, one of the layers is missing, as in Ingleborough itself.

Since this lecture was delivered, much attention and interest have attached themselves to this area on account of the newer work of the palæontologists, and it now seems to be more than probable that we shall have no longer to look to the "Yoredales" of Phillips as a separate series, lying between the Carboniferous Limestone and the Millstone Grits, but to regard them as belonging to the Great Scar Limestone; which, owing to changing conditions of deposition, splits up northward of the Craven faults. If this be the correct view, and the newer evidence has not been seriously contested, we have to abandon our old ideas of the Yoredales, and class them in with the Lower Carboniferous rocks. Yorkshire geologists will inevitably accept the new conclusions with the keen regret which accompanies the passing of an old friend, and it must be left to a newer generation to adopt the mental habit of regarding the Yoredale series as other than a distinct and separate entity in the great Carboniferous formation.

However that may be, Ingleborough will always possess a fascinating interest for Yorkshiremen as an index to the Geology of the north-west Yorkshire mountains, fells, and valleys.

The student who has mastered the geology of Ingleborough possesses the key to a clear understanding of the Carboniferous rocks of Upper Airedale, Upper Wharfedale, Wensleydale, Swaledale, and away to the Scottish border. Dropped into any of these north-west valleys he would soon recognise familiar features in the contours and the landscape, and be able to correlate them with the text-book he had studied from nature in Ingleborough.

Ingleborough is ever an interesting sight to tourist or geologist, rearing its majestic head fully 1,800 feet above the villages at its foot, and exposing on its slopes evidences of the denuding agencies that have gashed its sides, and cut down into its very foundations. Ingleborough may be taken as an index of the Lower Carboniferous rocks of Yorkshire, north of the Craven faults, to the top of the Yoredales, with the "Underset" limestone missing. In the Yoredale district, as at Stake Fell, the valleys are cut below the "Great Scar" limestone. In Swaledale the lowest limestone cut down to is the "Hardraw Scar," below Muker. Counted as Yoredale beds there are five limestones, which are very persistent over the area, divided from each other by shales, sandstones, and grits, and surmounted on most of the high grounds by the Millstone Grit. These are the "Hardraw Scar" limestone, named from the well-known scar and foss near Hawes; the "Simonstone." named from the next limestone bed topping the "Hardraw" Scar at Simonstone on the slopes above Hardraw Scar; the "Middle" from the

fact that it *is the middle one of the five limestones ;* the "Underset." because it is *set under* the "Main" limestone; and the "Main," because, when cut-cropping, it forms the main or principal feature of the hill-side contours in all the valleys where the Upper Yoredale rocks prevail.

Proceeding from the village of Ingleton towards the summit of the mountain, Lower Silurian rocks are exposed in Beezley Falls and Baxendale Gorge. These rocks lie with their edges upturned at a high angle, and *if there is no repetition of beds*, they represent a thickness of about 10,000 feet. The Silurians are of marine origin, but after deposition were uplifted and folded, forming dry land in Devonian times. They were subjected to enormous denudation, by which thousands of feet of Upper Silurian rocks were removed. After the Devonian period, this area sank again beneath the sea, and on the uneven surface of ridges and hollows were deposited, first conglomerates, and then the "Great Scar" limestone, as seen at Ravenscar and Crummack Beck Head. It is this limestone that gives to the country such interesting features as the Cove at Malham, the Gorge at Gordale, the Clints of Malham Moor, and the numerous caverns and pot-holes, such as Gaping Gill and Rowton Pot. This limestone is of varying thickness, from 2,000 feet in Derbyshire, to 2,500 feet in the Mendips; in the Ingleborough district from 600 to 750 feet, gradually thinning northwards towards Durham, Northumberland, and the Scottish border, where it passes into shales and sandstones, which appear to indicate the shore-line in that direction. Where the limestone fills up hollows in the Silurian floor it contains more marine fossils than its higher beds, the variation in depth of sea, and the influence of currents, probably accounting for the difference.

Continuing the climb up Ingleborough, the steep limestone is succeeded by the gentler slopes of the shales. These shales vary from 30 feet here to 70 feet on Dodd Fell, near Hawes, and at Buckden only a thin plate, while at Grassington they disappear, thus thickening towards the north-west, and thinning out eastwards. In Ingleborough the "Hardraw Scar" limestone is from 30 to 40 feet thick, in Greygareth 40 feet, and in Kingsdale 40 feet. Like some of the upper layers of the "Great Scar" limestone, it is everywhere dark in colour, sometimes almost black. The most characteristic fossils are *Productus giganteus*, and Crinoids. After another 150 feet of sandstone and shale we come to the "Middle" limestone, of a lighter colour, which can be seen above Gaping Gill Hole, and under Little Ingleborough. In Wensleydale it forms the ledge over which Aysgarth Force falls. The next limestone, the "Underset," is missing in Ingleborough, but is found to the north-west, in Whernside, with a thickness of 7½ feet, and in Coal Gill, two miles north, with a thickness of 25 feet. Next come about 200 feet of shales and shaly sandstones, and then 200 feet

of sandstones with shales. Evidently shore deposits were rapidly accumulating and altering the conditions. This sandstone forms the top of Little Ingleborough, and the main northerly lobe of Simon Fell. Opposite Chapel-le-Dale it forms a fine escarpment, the third bold scarp in the mountain, counting from the top, and is one of the most prominent features of the upper mountain. Over this comes the "Main" limestone, which tops the Yoredale series. It forms a fine white scarp between the Millstone Grit above, and the thick sandstones below, and is from 50 to 60 feet thick, often full of encrinital remains. It forms the fine waterfall of Kisdon Force, and many others in the north-west dales.

The Ingleborough Grit is not the lower or first deposited, as is that on Penyghent, but is the second. Evidently the gritty material coming from the north and north-east at first only reached Penyghent, and finer shaly material reached Ingleborough, but as the transporting power increased, the rougher matter was carried farther west.

From a comparison of all the sections showing the complete Yoredale series, it is found the beds thicken northward and north-east, but thin out eastwards and south-east. This is true particularly of the land-derived deposits. As regards the limestones, the three lower ones—"Hardraw Scar," "Simonstone," and "Middle," thin out southwards and eastwards; the "Underset" and "Main" thicken to the north-east and east. The intervening shales and sandstones are thinner apparently in inverse ratio, and thin rapidly where the three upper limestones are thickest. It looks as if the materials came from the west to the north-west more than north in the later stages, while in the shore-derived deposits between the "Hardraw Scar" and "Middle" limestones, the easterly thinning is perhaps less marked, and they may have come from the north.

A study of the following table (see next page) will show the relative thickness of the several limestones and intervening sandstones and shales in different parts of the area covered by the Yoredale rocks.

The geologist who wishes to study Ingleborough will do well to ascend the mountain from as many different points as possible, but the five routes following are essential to a clear knowledge of the whole structure, since certain features which will not be seen or recognised by one route may be noted and studied by another.

ROUTE I.—The gorges in the Lower Silurians (Ordovician) of the Pecca Falls, Thornton Force, and Beezley Falls. By Gods' Bridge and the "Granite" Quarries up to the basement beds near, and just above Skirwith, over Ravenscar, and up the south-west front of the mountain.

ROUTE II.—By Jenkin Beck (noting the Coniston limestone) up by Crina Bottom, and over the sandstone forming Little Ingleborough, to the top.

	Great Scar.		Hardraw.		Simonstone.		Middle.		Underset.		Main.	Total.	
Ingleboro' ..	30	30	100	25	150	15_{20}	200	..	200	50	810		
Whernside .. East Slopes, So. End.	..	2 Thins	175	20	120	40	..	25	450	50	855		
Scotchergill and Cragg Fell ..	S.G. 140	25	78	18 =	C.F. 132	18	390	25	80	10_{15}	920		
Raydale ..	132	50	76	30	130	30	270	50	80	90	938	Providence Mine, near Kettlewell,	
Widdale Fell .. Below.	120	70	80	25	110	70	300	20	70	75	940	Yoredales,	
Dodd Fell .. To Hawes.	84	75	80	30	100	50	350	30	80	90	969	305·7 feet only.	
Outershaw ..	..	60	180	30	120	50_{80}	300	30	80_{90}	100	990		
Little Fell .. Nr. Yockenthwaite.	100	..	65	60	35	45	180	65	130	60	740		
Bishopdale ..	*Thin*	50_{35}	80	30	130	50	245	60	50	100	795		
Deepdale .. .. Wharfedale.	40	40	80	25	110	40	230	50	53	50	718		
Buckden Beck ..	Thin Plate	30	60	40	30	110	100	100	40	100	610		
Outershaw .. To Kettlewell.	Thinning So. East	Runs into G.S.L., So. East	..	..	Feeble to So. East	..	Thinning out, So. East.	To Chert at Cam Head Near Kettlewell	..	Thinning So. East	..		

N.B.—The several limestones are named. The intermediate figures represent the thickness of the shales and sandstones lying between.

ROUTE III.—From Clapham by Trow Gill, Gaping Gill Hole, up Fell Beck, and over the exposure of the Middle limestone to the top.

ROUTE IV.—By Norberfoot (noting the basement beds beneath the Scarp) up Crummack Dale to Austwick Beck Head (noting the uneven thickness of the Scar limestone and the ridges in the underlying Silurian floor), up over the Scarp and by Long Kin East to the top of Simon Fell, then along Simon Fell, noting the Main limestone, to the top.

ROUTE V.—From the Hill Inn in Chapel-le-Dale, noting all the principal features of the Great Scar limestone, working up any or all of the upper streams which sink into the Scar limestone; noting also the fine sandstone scarp which underlies the Main limestone, then round to the left by the depression between Simon Fell and the top of Ingleborough.

REFERENCES.—Particular attention is directed to the following:—

"Geological Survey Memoir, Ingleborough, &c." 1890.

HIND & HOWE.—"The Pendleside Group at Pendle Hill." Q. J. G. S. vol. lvii., 1901.

Dr. W. HIND.—"The Subdivisions of the Carb. Series in Great Britain, &c." Proc. Edinburgh Geol. Soc., 1898.

Prof. T. MCKENNY HUGHES.—"Ingleborough." Proc. Yorks. Geol. and Polyt. Soc., vol. xiv., part 2, 1901, part 3, 1902; vol. xv., part 3, 1905.

"The Underground Waters of Ingleborough." Proc. Yorks. Geol. and Polyt. Soc., vol. xv., part 2, 1904.

Dr. W. HIND.—"The Characters of the Carboniferous Rocks of the Pennine System." Proc. Yorks. Geol. and Polyt. Soc., vol. xiv., part 3, 1902.

Much valuable work has been done during the past two or three years in determining the exact faunal sequence in the Carboniferous Limestone rocks of various areas in this country, with a view to the correlation of the different beds, both here and on the Continent. Since Dr. A. Vaughan published an account of his work in the Bristol area,* taking the corals and brachiopods as indices of his zones, his classification has been applied by other workers in the Mendips, South Wales, Co. Dublin, and East Derbyshire. Quite recently the investigation of the Carboniferous Limestones of Yorkshire, on the same lines, has been started by Mr. Cosmo Johns, M.I.Mech.E., F.G.S., who commenced with the beds exposed in Ingleborough, and has published preliminary reports of his work in "The Naturalist," July, 1906; and the "Geological Magazine," July, 1906. (*Eds.*)

REFERENCES TO SUBJECTS OF OTHER PAPERS READ:

"THE GEOLOGY OF NORTH WALES." P. F. KENDALL, F.G.S.

RAMSAY.—"GEOLOGY OF NORTH WALES." (Geol. Survey Memoir). 1881.

"THE GEOLOGY OF THE CHEVIOTS." P. F. KENDALL, F.G.S.

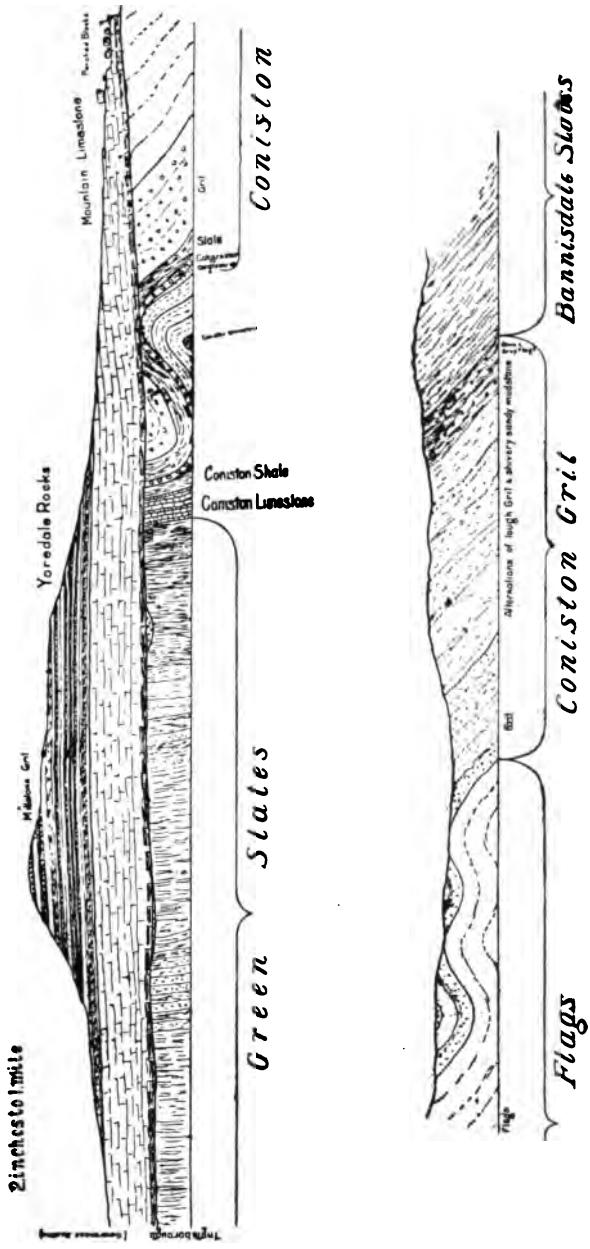
P. F. KENDALL & H. B. MUFF.—"GLACIATION OF CHEVIOTS." Geol. Mag., 1901. p. 513. Proc. Edinburgh Geol. Soc., 1902.

Mem. Geol. Survey.—"THE CHEVIOT HILLS" (English Side), 1888.

A. GEIKIE.—"ANCIENT VOLCANOES OF GREAT BRITAIN." Vol. I., p. 336.

J. GEIKIE.—"FRAGMENTS OF EARTH LORE." p. 62.

* Q.J.G.S., vol. lxi., 1905.



GENERALISED SECTION ACROSS INGLEBOROUGH.
(*Block kindly lent by the Yorkshire Geological Society*).

TWENTY-EIGHTH SESSION, 1901-1902.

Officers:

President: DAVID FORSYTH, M.A., D.Sc.

Vice-President: GODFREY BINGLEY.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretary: WALTER PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council:

J. E. BEDFORD, F.G.S.
JNO. W. BOND.
A. R. DWERRYHOUSE, B.Sc., F.G.S.
REV. W. L. CARTER, M.A., F.G.S.
C. D. HARDCASTLE.
E. HAWKESWORTH.
B. HOLGATE, F.G.S.
J. H. HOWARTH, F.G.S.
P. F. KENDALL, F.G.S.
C. T. WHITMELL, M.A., B.Sc.

ANNUAL REPORT.

Your Council has pleasure in reporting that the session has been marked by increased interest in the work of the Association. As a result of the vote of the members the night of meeting has been changed from Wednesday to Friday, which has led to larger attendances.

During the session eight Meetings have been held, as follows :—

1901.

Oct. 22—SPECIAL PUBLIC MEETING in co-operation with other Leeds Scientific Societies.

Lecture by JAMES STIRLING, *President of the Geological Society of Australasia, &c.*, on "Researches into the Geology, Botany, and Meteorology of the Australian Alps." (*Lantern illustrations.*)

Nov. 21—PRESIDENT'S ADDRESS :—"The Aims of a Local Geological Society."

"The Circulation of Salt in its Relations to Geology." W. ACKROYD, F.I.C., F.G.S. (*Illustrated by diagrams and lantern slides.*)

Dec. 20—"Geology at the British Association." P. F. KENDALL, F.G.S.

"Exhibition of a model of Ingleborough." A. R. DWERRYHOUSE, B.Sc., F.G.S.

1902.
Jan. 17—"The Neapolitan Volcanoes." Rev. W. L. CARTER, M.A., F.G.S. (*Illustrated by maps and lantern slides.*)

Feb. 21—"The Prehistoric Inhabitants of the Yorkshire Wolds." THOS. SHEPPARD, F.G.S. (*Illustrated by lantern slides and specimens.*)

Mar. 21—"The Geology of the North-West Highlands." P. F. KENDALL, F.G.S. (*Illustrated by maps, lantern slides and specimens.*)

April 23—"Report of the Magnesian Limestone Committee." A. R. DWERRYHOUSE, B.Sc., F.G.S. (*Illustrated by map, lantern slides, and specimens.*)

Exhibition of Coloured Photographs of Geological Maps, also of a new method of making rock sections. A. R. DWERRYHOUSE, B.Sc., F.G.S.

"Notes on some Geological Excursions." E. HAWKESWORTH.

June 3—ANNUAL BUSINESS MEETING.

The Association now consists of 10 Honorary, 63 Ordinary, and 2 Associate Members, an increase of 5 over last session.

The Committee appointed for the investigation of the nature and origin of the Magnesian Limestone has made a series of observations in the Garforth district.

An attempt has been made to bring about a closer bond of union between the various Scientific Societies of the City, and a meeting of their representatives has been held, from which beneficial results are anticipated.

The Treasurer's report shows receipts of £18 11s. 4d., and expenses £15 18s. 4d., leaving a balance in hand of £2 13s.

"THE AIMS OF A LOCAL GEOLOGICAL SOCIETY."

Abstract of Presidential Address delivered by Mr. DAVID FORSYTH, M.A., D.Sc., *November 21st*, 1901.

The primary aim of such a society is to serve as the gathering ground for all interested in geological enquiry, whether for lectures from the learned, for exchange of opinions among the workers, for exhibition of specimens by the collectors, or for questions from the struggler towards knowledge and truth. Its membership should be of a kind broad enough to include men of the highest scientific attainments, and the humblest workers who love Nature, and find "sermons in stones." For a local geological society to be too scientific would be to make learners hold aloof; to be too elementary, on the other hand, would not lead to the instruction of the students. By a kind of scientific and social segregation, all sorts and conditions of men are nucleated by a common interest in things geological. All that is needed for membership is an earnest love for the subject, and an equally earnest desire to learn from the other members. The humbleness of attainment should never prevent any man from becoming a member, if only it be in keeping with the true humility of the student, and that humility which should especially characterise a geological association, considering the profundity and infinitude of the questions with which it has at times to deal.

In no association of men is there so much of "give and take" as in a geological association. In papers, observations of the simplest kind should merit attention, and short papers by the younger members would afford an opportunity of kindly criticism and help at the hands of the seniors, who would remember lovingly their own early endeavours. Such papers, as encouraging systematic observation, the consultation of authorities—the first step to work of real scientific value—and independent thought, would be a training in themselves to the writers, and would be a joy in awakening the slumbering echoes of enthusiasm in others, not now geologically young. Papers of general geological interest are of benefit to all members, but especially to the young student, who, fresh from his text books, finds from the personal knowledge of the expert a living interest far beyond that of the printed page. New theories, or revivals of old ones, form the staple for other papers, by which the members are kept up-to-date in a rapidly developing science.

Local research is the very life of a local society, and it may take many forms. It may be stratigraphical, taking cognisance of the transient revelations of quarries and railway cuttings, and even city geology has its field in this respect. More often it is palæontological, making a faithful record of every evidence of the past life of the district. Frequently it is photographical, recording with absolute accuracy sections that soon may be obliterated, or pourtraying the life-forms of a geological period. The minute structure of rocks has led many members to microscopical enquiry. Just as the variation in the composition of rocks, so the substitution of rock materials, the gradual increase or decrease in the percentage of constituent elements or compounds, and the changes still going on in nature, have opened a wide field for chemical geology. While, again, the relations that local strata have to similar ones in other areas, such as the relation of the Carboniferous zones on each side of the great Pennine backbone, are of surpassing interest and practical value.

Sub-committees should be appointed to work out in every detail the local formations. The investigations of *Mr. J. W. Bond in the local Coal Measures are a pattern to all young students. The Magnesian Limestone has a committee specially concerned in examining the stratification, fossils, composition, and economic value of the deposit.† The Millstone Grit needs another to examine thoroughly its origin, its formative material, and its intercalated beds of shales. And the district of Ingleton tempts many workers desirous of knowledge of the older rocks of the country.

† See pp. 45-48 of this volume.

* Transactions Leeds Geological Association, Part XII.

The field of geological inquiry is broadening, and, it seems more than ever to make demands on all kindred sciences ; chemistry, crystallography, mineralogy, physics (terrestrial and solar), microscopy, botany, and zoology. Such demands make a geological association ready for co-operation with other local scientific societies, and are one of the main causes of the *camaraderie* of the "hammermen."

Social intercourse of an intelligent nature is one of the primary needs of a civilised community. The difficulties of such societies are due not so much to the old members losing interest, and dropping out of active membership, as to the want of the introduction of new, young, and enthusiastic workers. The very successes of life, and its responsibilities and dignities, tend to take away the older members. A witty Glasgow geologist used to say that his first test as to the active work of a friend was "waist measurement," and his second the activity with which a five-barred gate, or a stone wall, could be negotiated. With such tests, therefore, there is a constant demand for new workers and observers, who will come to the meetings bearing their harvest treasures—the results of faithful study, intelligent observation, and persevering application.

Let the members live up to the privileges and responsibilities of the association, and keep up the high standard of its ideal, observation, interchange of ideas, mutual helpfulness, and that genial humaneness which should characterise all those who seek in the blessed open air for that revelation of light and truth which the Almighty, in His wondrous working, has stored up in His earth as in a treasure house, for the humble and faithful disciples of Nature.

REFERENCES TO SUBJECTS OF OTHER PAPERS READ :

"THE CIRCULATION OF SALT IN ITS RELATIONS TO GEOLOGY." W. ACKROYD, F.I.C., F.C.S.

ACKROYD.—"ON THE CIRCULATION OF SALT AND ITS BEARING ON GEOLOGICAL PROBLEMS, MORE PARTICULARLY ON THAT OF THE GEOLOGICAL AGE OF THE EARTH." Proc. Yorks. Geol. and Polyt. Soc., vol. xiv., pt. 3, 1902.

"THE PREHISTORIC INHABITANTS OF THE YORKSHIRE WOLDS." THOS SHEPPARD, F.G.S.

SHEPPARD.—"HULL MUSEUM PUBLICATIONS."

MORTIMER.—"FORTY YEARS' RESEARCHES IN BRITISH AND SAXON BURIAL MOUNDS OF EAST YORKSHIRE."

"THE GEOLOGY OF THE NORTH-WEST HIGHLANDS." P. F. KENDALL, F.G.S.

PEACH, HORNE AND OTHERS.—Q.J.G.S., xliv. (1888), p. 378.

TWENTY-NINTH SESSION, 1902-1903.

Officers:

President: DAVID FORSYTH, M.A., D.Sc.

Vice-President: GODFREY BINGLEY.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretary: WALTER PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council:

T. ASHLEY.
J. E. BEDFORD, F.G.S.
JNO. W. BOND.
Rev. W. L. CARTER, M.A., F.G.S.
A. R. DWERRYHOUSE, B.Sc., F.G.S.
C. D. HARDCASTLE.
E. HAWKESWORTH.
J. H. HOWARTH, F.G.S.
P. F. KENDALL, F.G.S.
C. T. WHITMELL, M.A., B.Sc.

ANNUAL REPORT.

Your Council has pleasure in reporting a successful session, marked by another increase of members, and by a series of excellent papers. The attendance of members—whilst leaving something to be desired—has been much better than was the case two years ago. This probably is due partly to the change of meeting-night.

The Association now consists of 9 Honorary, 68 Ordinary, and 2 Associate Members, an increase of 5. Two of its oldest and most valued members, Messrs. James Bedford and C. D. Hardcastle, have died during the session.

Eight evening Meetings have been held, as follows:—

1902.

Oct. 17—PRESIDENT'S ADDRESS:—"The Causes of Volcanic Action."

Nov. 21—"Geology at the British Association." E. HAWKESWORTH and P. F. KENDALL, F.G.S.

Dec. 19—"Geological Photography." GODFREY BINGLEY. (*Lantern illustrations.*)

1903.

Jan. 16—"The Glacier Lakes of the Cleveland Hills." P. F. KENDALL, F.G.S. (*Illustrated by maps and lantern slides*).

Feb. 20—"Prospecting in Vancouver Island." Prof. G. R. THOMPSON, B.Sc., F.G.S.

Mar 10—"The West Indian Eruptions." (In co-operation with the other Scientific Societies of Leeds.) Dr. TEMPEST ANDERSON, B.Sc., F.G.S. (*Lantern illustrations.*)

April 21—"The Underground Waters of Ingleborough." A. R. DWERRYHOUSE, B.Sc., F.G.S.

1903.
May 15—ANNUAL MEETING.
"Report of Magnesian Limestone Committee."
Exhibition of maps, models, apparatus, and specimens in the Geological Laboratory of the University of Leeds, by the Geological Staff.

The following excursions have been held :—

1902.
Sept. 1—Hambleton and Draughton. Leader, Rev. W. L. CARTER, M.A., F.G.S.

Oct. 18—Examination of glacial overflows near Bradford. Leader, J. E. WILSON.

Dec. 29—Pontefract and Castleford. } Leader, A. R. DWERRYHOUSE, B.Sc., F.G.S.
Dec. 30—Kippax, Ledsham, and Micklefield. }

1903.
April 14—Clapham, Norber and Ingleborough. Leader, Rev. W. L. CARTER, M.A., F.G.S.

The thanks of the Association are due to the gentlemen who organised and led the above Excursions.

"THE CAUSES OF VOLCANIC ACTION."

Abstract of Presidential Address delivered by Mr. DAVID FORSYTH, M.A., D.Sc., *October 17th*, 1902.

The disastrous eruptions in the West Indies have excited the interest of the peoples of both hemispheres, and have revived the speculations as to the causes of volcanic action. The subject is one of perennial interest to geologists, inasmuch as it involves in its consideration questions as to the state of the earth's interior, movements of the earth's crust, volcanic action in remote ages in the British area, and the influence of such agency on its strata.

The popular definition of a volcano as a burning mountain is scarcely correct, as a volcano is not necessarily a mountain, and it does not burn. The scientific definition is more general—an opening in the earth's crust, from which issue gaseous, liquid, and molten material.

The most common and important of the gaseous materials is steam. In an eruption of Mount Etna in 1865, Fouqué calculated that the amount of water-vapour ejected would, if condensed, have equalled 5,000,000 gallons of water daily. Whence comes this enormous amount of steam? Abundant observations have proved (1) that diurnal changes of temperature do not affect the earth below a depth of 3 feet, and seasonal changes do not affect it beyond 40 feet; (2) that a zone of invariable temperature occurs at varying depths, and that below that the temperature increases 1° F. for about every 50 feet. A temperature of 212° F. would be reached about 8,000 ft., and at a depth of 30 miles the heat would be such as to melt all known substances. At the same time it must be remembered that pressure exercises an influence on the

boiling point of water, and the fusing point of metals. The pressure of water at 212° F. is equal to that of one atmosphere, but at 432° F. to that of 24 atmospheres. Water, therefore, may exist as heated water at great depths, until its critical temperature—773° F.—is reached, according to Prestwich's table. Further, Delesse considered that the pressure of the overlying strata, and the resistance they offered to water tension, might account for water retaining its liquid condition even at greater depths. But he estimated that at a depth of 60,000 ft., and at a temperature of 1,100° F., the overlying pressure and the elastic force of water would be in equilibrium. It is easy to understand that at such temperatures (1) the solvent power of water is increased greatly, and (2) that the temperature of rock fusion is lower than if it were due to dry fusion.

How comes the water to such depths? The porosity of rocks, the transmission of water by percolation and by fissures are too well known to local geologists to call for any special notice. The fissures in volcanic districts are more numerous, and from them, and from the transmission along the planes of stratification, water finds an easy passage downwards. It has been argued that steam would drive back by these very fissures the percolating water, but the experiments of Daubree go to prove that water may be transmitted downwards through porous sandstone against a steam pressure of two atmospheres.

Water in conversion into steam occupies 1,700 times more space, or in other words, exercises a tension 1,700 times more than water. Such a sudden conversion is more explosive than gunpowder. The difficulties pointed out by physicists and geologists in regarding water as the primary force in volcanic eruptions are:—(1) The presence of water in deep-seated volcanoes; (2) the insufficiency of water as the elevating force from great depths; (3) the want of agreement in time and proportion between the discharge of steam and the discharge of lava. Other vapours present in volcanic eruptions are hydrogen, sulphuretted hydrogen, oxygen, nitrogen, carbonic acid, sodium chloride, boracic acid, etc.

Lava is the generic name given to the molten ejectamenta, no matter what its mineralogical composition may be. It overflows sometimes from the lip of the crater, but more often from fissures in the sides, and, in the case of Hawaiian volcanoes, by jets produced by the static pressure of the overtopping mountain. Lavas vary in fluidity, due to differences in composition, or heat, or the presence of water. There is great variability in the materials ejected, even from volcanoes situated near each other.

How comes the lava to the surface? The earth is a cooling planet, and contraction accompanies the loss of heat. The earth movements due to contraction are either (1) continental—long sweeps or curves—or (2) local, the evidences of which in puckering, faulting, overlapping, and over-thrusting are so well seen in many parts of the British Isles. The fractures caused by such earth

movements would relieve the pressure, and the internal plastic material, of which it is supposed the interior of the earth is composed, would become molten, and pass upwards through the fissures. Subsequent movements might form laccolites, or great reservoirs of molten matter, in the depths of the upper crust, and from these, by later movements, lava might reach the surface. This theory would account for some lava flows coming to the surface without explosions. Fisher thinks that water was contained in the early geological formations, and reached the volcanic foci in this way, and his opinion has been followed by Shaler, an American geologist, who further argues that the thickening of sedimentary deposits would carry down water-laden rocks to the heated interior.

More recently, I. C. Russell, another American geologist, points out that contraction sufficiently accounts for the upward rise of the molten lava from miles below the surface, and that in the upper strata its meeting with water percolating from the land surface and from the sea, accounts for the explosive phenomena of many eruptions. In stating his arguments, he points out that the proximity of volcanoes to the sea does not indicate necessarily the primary importance of water, for geologists generally are agreed that all these old sea lines are lines of structural weakness, from frequency of elevation and depression. From careful consideration of all these arguments, the hypothesis generally accepted at present is that expressed by Prestwich (1887) that the primary cause of eruptions is "the slight shrinking and contraction of the earth's crust, and its consequent pressure upon a viscous or plastic molten magma or layer beneath."

Reference was made to the theory of Mallet (1873) that the crushing of rigid material by earth movements would produce heat sufficient to fuse rocks. It was argued that without doubt, such heat would account for local fusion and metamorphism of strata, but would not be sufficient for volcanic eruption.

Allusion was made also to the chemical theory of Davy, to those of Sterry Hunt and others, also to the influence of atmospheric pressure in volcanic eruptions.

REFERENCES :—

FOUQUE.—"Santorin et ses eruptions." 1879.

DELESSE.—"Bulletin de la Societie Geologique de France."

PRESTWICH.—Geology," vol. 1, chap. 12, 13.

DAUBREE.—"Géologie Experimentale."

FISHER.—"Physics of the Earth's Crust." 1883.

SHALER.—"Outlines of the Earth's History."

RUSSELL.—"The Volcanic Eruptions of Martinique and St. Vincent."

MALLET.—"On Volcanic Energy." Philosophical Trans., 1873.

DAVY.—"Researches, Chemical and Philosophical."

STERRY HUNT.—"Chemical and Geological Essays."

JUDD.—"Volcanoes."

DUTTON.—"Hawaiian Volcanoes." Report of U.S. Geol. Survey, 1882-3.

"GEOLOGICAL PHOTOGRAPHY."

Abstract of Paper read by Mr. GODFREY BINGLEY, *December 19th*, 1902.

It is only necessary to compare some of the modern geological works with their admirable reproductions of photographs taken from nature itself, with some of the crude and often untruthful representations given in many of the early geological books, to see the great value of photography for purposes of illustration.

Professor Watts, of the Birmingham University, in a recent paper, said :—" for educational purposes it would be a very good thing to *replace* many of the venerable drawings which have so long done duty in the text books for representations of unconformity, bedding, cleavage, joints, faults, contortions, and many other elementary phenomena, *by reliable photographs*, representing the actual facts to the student as he will really see them."

Photography applied to geology has been the means of securing many records of valuable geological features during the past few years, which otherwise would have been lost. Often in the course of excavations in connection with new railways, reservoirs, quarries, &c., very interesting sections are exposed, which, from the exigencies of the work in progress cannot be allowed to remain, and, unless photographed at once, important geological facts may be lost to the student.

The coast-line of our country is undergoing constant change from the erosive action of the sea, and atmospheric denudation, and if a complete photographic survey of the coast could be made, it would be of great value and interest in future years for showing the changes that have taken place.

Likewise our land surfaces, besides the sudden and well-marked changes caused by earthquake or volcanic eruptions, are subject to a continuous wear and tear, affecting, in time, changes of contour and feature, in the recording of which photography is invaluable.

In 1889, on the suggestion of Mr. O. W. Jeffs, the British Association formed a committee for the purpose of collecting and preserving photographs of geological interest in the United Kingdom. Up to 1904 it had received over four thousand such photographs, which have been classified and indexed, and are placed in the Jermyn Street Geological Museum for the purpose of reference by students and the public. In addition to this permanent collection, a duplicate one of about 300 prints, and upwards of 100 slides, has been formed for lending out to any society that may make application for them, the cost of carriage being the only expense. This collection is intended to illustrate some of the most typical geological facts. For the use of students and others interested in geology a selected series of 72 photographs has been issued, and may be purchased at a moderate price.

The Yorkshire Naturalists' Union also has a "Geological Photograph Committee," which is accumulating an extensive and interesting collection of photographs relating to the county.

By a splendid series of slides it was demonstrated how much photography may be utilized for recording geological phenomena, thereby helping the student to realize many interesting geological features in a manner that he could not do from sketches or diagrams.

"THE UNDERGROUND WATERS OF INGLEBOROUGH."

Paper read by Mr. A. R. DWERRYHOUSE, B.Sc., F.G.S., *April 21st*, 1903.

A fully detailed account of this original, important, and highly interesting work, illustrated by numerous maps, diagrams, and photographs was published in the Proceedings of the Yorkshire Geological and Polytechnic Society, vol. xv., part 2, 1904.

"GLACIER LAKES IN THE CLEVELAND HILLS."

Abstract of Paper read by Mr. P. F. Kendall, F.G.S. *January 16th*, 1903.

When a glacier or ice-sheet advances against or across the general slope of a country which is not occupied by ice, there will be a tendency for its edges to obstruct and impound the natural drainage, and to produce lakes. The Alps furnish few examples of such lakes, as they are developed best where the relief of the country is low, and the ice-streams large. Many examples are found in Norway, but the great glaciers of Arctic North America, and the ice-sheet of Greenland, provide the finest illustrations.

The evidences by which ancient glacier lakes can be recognised are mainly four:—(1) Beaches; (2) Deltas; (3) Floor Deposits; (4) Overflow Channels. To these might be added the *a priori* arguments of Professor Carvill Lewis, who considered that the existence of such lakes could be deduced from the ascertained position of the ice front.

These lakes would be more or less temporary. The water would accumulate until it reached the level of the lowest part of its boundary, and there would overflow. It may find a way of escape either over or through the ice, in which case the only evidences of the lake, after the retreat of the glacier, will be beaches, deltas, or lacustrine deposits. On the other hand, the lake may drain by an overflow across a col or spur, in which case the water will cut a channel, which will remain a permanent record of the lake. These overflow channels may be either "anomalous" or "deserted."

Should the ice-barrier remain for sufficient time, or leave a moraine of sufficient height, the overflow will excavate its channel until it is deep enough to drain the lake completely, and take the normal drainage of the country. This would be an anomalous gorge, the original line of drainage below the moraine being left a deserted valley. On the other hand, by the removal of the ice-barrier, the old line of drainage may be resumed, causing the overflow channel to be abandoned or deserted.

Both classes of overflow occur in the Cleveland Hills. The anomalous ones are simple in character, the deserted ones are more complicated, and may be divided into four classes :—(1) Direct Overflows ; (2) Severed Spurs ; (3) Marginal Overflows ; (4) In and Out Channels. These channels have many peculiar features, differing widely from normal valleys. They are entirely independent of the natural drainage, and cut across the natural watersheds, often being deepest where they cut through it. Their fall usually is very small near the head, and rapidly steepens down stream. They have very steep sides, and, usually, wide, flat floors.

In the Glacial Period, the Cleveland area was invaded by ice-sheets, which reached a considerable height on its western, northern, and eastern slopes, thus blocking and impounding the natural drainage, and forming a series of lakes which drained from one to another, finally discharging their waters into a large lake in the Vale of Pickering, the overflow of which passed through a gorge in the Howardian Hills, near Malton, into the Vale of York.

At the present time the whole drainage of the country south of the Esk, except a strip of a mile or two broad, north of Scarborough, enters the Vale of Pickering, and, instead of taking the natural and direct course to the sea at Filey, it is all diverted against the slope of the rocks, and the grain of the country, and passes out by the Derwent, into the Vale of York, by the gorge at Kirkham Abbey. This marked modification of the drainage system of a large area was produced by the great thickness of Drift deposits, which block up the seaward end of the original valley.

References to Glacier Lakes :—

Carvill Lewis.—" Glacial History of Great Britain and Ireland." 1894.

I. C. Russell.—" Glaciers of North America." 1897.

C. Fox Strangways.—Geol. Surv. Mem. " Jurassic Rocks of Britain." Vol. I., Yorkshire.

P. F. Kendall.—" Glacier Lakes in the Cleveland Hills." Q.J.G.S., vol. lviii., 1902, pp. 471-571. Proc. Yorks. Geol. and Polyt, Soc., vol. xv., pt. 1, 1903.

A. R. Dwerryhouse.—" Glaciation of Teesdale, &c." Q.J.G.S., vol. lviii., 1902, pp. 572-608.

A. Jowett and H. B. Muff.—" Glaciation of Bradford, &c." Proc. Yorks. Geol. and Polyt. Soc., vol. xv., pt. 2, 1904.

W. L. Carter.—" Glaciation of Don, &c." Proc. Yorks. Geol. Soc., vol. xv., pt. 3, 1905, pp. 411-436.

THIRTIETH SESSION, 1903-1904.

Officers:

President: E. HAWKESWORTH.

Vice-President: DAVID FORSYTH, M.A., D.Sc.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretary: WALTER PARSONS, F.R.G.S

Hon. Librarian: JOSEPH LANG.

Members of Council:

J. E. BEDFORD, F.G.S.
GODFREY BINGLEY.
JNO. W. BOND.
F. W. BRANSON, F.I.C.
Rev. W. L. Carter, M.A., F.G.S.
A. R. DWERRYHOUSE, M.Sc., F.G.S.
J. H. HOWARTH, F.G.S.
P. F. KENDALL, F.G.S.
Prof. G. R. THOMPSON, B.Sc., F.G.S.
C. T. WHITMELL, M.A., B.Sc.

ANNUAL REPORT.

Your Council has pleasure in reporting a successful session, marked by an excellent and varied set of papers, and by an improved attendance at the meetings. Seven Evening Meetings have been held, as follows:—

1903.
Oct. 16—PRESIDENT'S ADDRESS:—"The Progress of Geology during the Nineteenth Century."
Exhibition of lantern slides of Swiss Glaciers, &c. GODFREY BINGLEY.
Exhibition of maps, models, specimens, &c. P. F. KENDALL, F.G.S.

Nov. 20—"Geology at the British Association." A. R. DWERRYHOUSE, M.Sc., F.G.S.

Dec. 18—"The Origin of the British Fauna and Flora." P. F. KENDALL, F.G.S.

1904.
Jan. 11—"A Geological Ramble along the Yorkshire Coast." THOS. SHEPPARD, F.G.S. (*Lantern illustrations.*)

Feb. 19—"The Relationship between the Vegetation and the Geology of the West Riding of Yorkshire." WM. G. SMITH, B.Sc., Ph.D.

1904.

Mar. 25—"The Coast Lines of Lancashire and Cheshire—their Forms and Origin." J. LOMAS, A.R.C.S., F.G.S.

Exhibition of Kimeridge Clay and Coal Measure Fossils. P. F. KENDALL, F.G.S., A. BURNET and S. NETTLETON.

May 20—ANNUAL MEETING.

"The Geology of the Lake District of South Perthshire." DAVID FORSYTH, M.A., D.Sc. (*Illustrated by maps, lantern slides and specimens.*)

Exhibition of lantern slides of Norfolk, Cheshire, North Wales, and Yorkshire. GODFREY BINGLEY.

Exhibition of maps, specimens, apparatus, &c. P. F. KENDALL, F.G.S., and A. R. DWERRYHOUSE, M.Sc., F.G.S.

Your Council has had under consideration the advisability of changing the place of meeting. As a result of investigations made by a Sub-Committee, a room in the Law Institute has been engaged.

The Association now consists of 7 Honorary, 66 Ordinary, and 2 Associate Members. It is sad to record the decease of Messrs. Washington Teasdale, F.R.M.S., H. A. Allbutt, and W. E. Asquith, three very old members.

The thanks of the Association are due to the readers of papers, to Mr. Arnold Lupton for the gift to the Library of a set of the Quarterly Journals of the Geological Society, and to the University of Leeds for the use of rooms for the opening and concluding meetings.

"THE RELATION OF THE GEOLOGY TO THE VEGETATION OF THE WEST RIDING OF YORKSHIRE."

Abstract of Paper read February 19th, 1904, by
WM. G. SMITH, B.Sc., Ph.D.

It is necessary before approaching the main subject of this paper to consider the factors which determine the distribution of plants over larger areas of land than Britain. The vegetation of a continent like Europe or America falls into regions which correspond to the tropical, temperate or arctic nature of the climate. The tropical forest, the evergreen trees and shrubs of the Mediterranean, the oak and beech forests of Central Europe, the pine forests of the north, and the treeless Arctic tundra are each, in the first place, determined by the prevailing climatic conditions. These also determine the contrast between the forest region of Western Europe and the steppes of Eastern Europe, between the Atlantic and Pacific coast forests and the treeless prairie of Central North America. While these primary divisions of the earth's vegetation depend mainly on climate, the geological formation has some influence, since the topography of a continent depends on the rocks and their

history. Mountains influence the climate, and in ascending them it is possible to pass from tropical vegetation to snow-clad summits, as in Central Africa. The close agreement between the distribution of forest, grassland, desert, tundra, and other great types of vegetation on the one hand, and the rainfall and other factors which go to make up climate on the other hand, has been demonstrated by Schimper in his " Plant Geography " (1904). One cannot, however, attempt to explain the different forms of vegetation met with in a small part of the earth like Britain on climatic grounds alone. The variation between the climate of the north and south of Britain is not great, when the great difference between an Arctic climate and a tropical one is borne in mind. In the extreme north of Britain there is in winter, a temperate type of Arctic winter, subject to much change, while in the south the climate is colder than the Mediterranean region, to say nothing of the tropics. The mountain climate of Yorkshire and Wales is not so very different from that found at similar elevations in Scotland. Nor is there the marked difference in the extremes of heat and cold between the plains of Britain and the comparatively low mountains, that one finds in the Alps, where the transition from olive groves and vineyards to the glaciers can be accomplished in a short time. The influence of climate on vegetation in Britain cannot be altogether neglected, for grapes can be ripened in the open in the south-west, but not in the north. The wheat crop is essentially one of the warmer parts, and is absent on much of the farmland because its ripening is uncertain. The ling may be given as another example ; it is much more abundant in the drier Eastern Grampians of Scotland than on the rainy Western side, and in Yorkshire the miles of almost pure heather of the Cleveland and North York Moors (rainfall, 25 to 35 inches per annum) become much restricted on the extensive moorlands of the Pennines (rainfall, 40 to 60 inches).

The varied nature of the vegetation of Britain or any part of it can only be explained if the soil conditions are taken into account. Certain relations between the distribution of geological formations and the plants growing on them have long been observed by geologists and botanists, so that terms like " limestone flora," " chalk flora," and " sandstone flora " are familiar. The geologist must not expect, however, a too close agreement between his geological survey map and the vegetation. It is superfluous to remind the geologist of the West Riding that the rocks below may bear little or no relation to the soil on the surface from which the roots of plants obtain their supplies. Deposits of alluvium, and the older glacial clays, sands and gravels may effectually cut off the underlying rock as a source of plant food. The formation of peat acts in the same way, and a layer of peat a foot deep or less is quite sufficient to deprive plants of any benefit from the mineral matter of the underlying rock.

The most striking feature in the distribution of geological strata and plants in the West Riding is the marked contrast between the vegetation of the Mountain Limestone and that of the adjacent sandstones and shales. On Great Whernside, Ingleborough, and any of the neighbouring summits and ridges which have limestone slopes and sandstone summit-caps, the contrast can be seen during a short excursion. The limestone pastures and scars are covered with short grass mixed with which are numerous plants, not grasses ; the whole forming a varied sward from which in June the botanist can collect many species in flower. The limestone vegetation indicates a good supply of mineral food, the full effect of which is lost by deficiency of water on the much fissured limestones. Passing upwards to the sandstones, there is more water, but much less variety in the species of plants, and the total amount of growth in a year is small, an indication that mineral food is deficient. Peat is generally present, and the plants are peat-plants, few of which will be found on the limestone. Bilberry, ling, and cloudberry are examples of the peat plants, while hoary plantain and moor blue grass (*Sesleria*) are limestone frequenters. The peat plants may be found on the limestone, but if so, then look for the peat at their roots. The formation of peat on flat places over the limestone is not uncommon, and it is an interesting problem how the water, which is so essential to the formation of peat, became lodged in these places instead of draining away as it generally does in a Mountain Limestone area. The occurrence of the peat is more important for the growth of peat plants, than the absence of limestone, although this latter is frequently stated to be the prime factor, and peat plants are regarded by many as "lime-shy." On the higher plateaux of the West Riding, such as High Mark, near Malham Tarn, and Moughton Fell on Ingleborough, this mingling of limestone plants with ling and bilberry can frequently be seen. The Mountain Limestone is strikingly deficient in woods, but a few occur near Kettlewell in Wharfedale, and the taller trees are chiefly ash. The absence of oak in the limestone woods is very marked, when compared with its general occurence in the Millstone Grit and Coal Measures. This feature is not confined to Yorkshire, for it is more marked in the Mountain Limestone dales of Derby. On the river deposits of Upper Airedale and Wharfedale, the oak may be found on the deeper soils, and its absence from the limestone slopes is due to lack of depth of the soils there.

The woods of the Calder basin consist chiefly of oak, sycamore and birch. Their distribution is influenced by geological features. On the open upland plateaux there are few woods, but on the sandstones and shales of the river valleys, the steep woods are familiar to travellers on the railways which pass into Lancashire. These woods are composed of trees of low stature, and both in the trees and the undergrowth present a distinct contrast to the Coal Measure

oak woods (e.g., round Cudworth and Barnsley). On a vegetation map, the woods follow the river valleys of the Millstone Grit area as narrow strips, while the Coal Measure area can be distinguished by its rounded woods which top the watersheds in many places.

The eastern part of the West Riding is geologically Permian or Triassic, but a careful study of the agricultural land and the woods will soon reveal a great variety in vegetation. The glaciation of this part has produced soils of all classes from the poor sands to deep loams mixed with all kinds of rocks from the dales. The change from one type of vegetation to another is so frequent that within a single farm the extremes of poor and rich land may be found. As regards the woods, it will be found as a rule that a plantation or fox covert of pine trees indicates the poorer lands, while tall beech and oak are confined to the more fertile soils.

The influence of soil upon vegetation is so marked, that neither the geologist nor the botanist can ignore it. Our own experience has been that if a distinct change of vegetation is noted in passing from one place to another, there is generally a corresponding change in the surface geology. The main factors are probably the water supply, and the water-holding properties of the soil ; this, however, requires further observation, and is a common ground on which the geologist and the botanist may work with profit.

"THE ORIGIN OF THE BRITISH FAUNA AND FLORA."

Abstract of Paper read by Professor P. F. KENDALL, M.Sc., F.G.S., *18th December*, 1903.

The British fauna and flora may be said to contain three elements—firstly, the main body of the animals and plants agrees closely with those of the great Germanic lowlands, and may be termed the Germanic element. Its distribution in the British Isles suggests that it entered Britain from the south-east or east, and advanced in a great wave towards the west and north. The second element is a small group of animals and plants having their head-quarters in a circumpolar belt surrounding the North Pole, with isolated colonies in our own country and in the mountain centres of Europe, and may be called the Arctic and Alpine element. The third element, the Lusitanian or Southern, includes a particular species of slug, and the well-known Killarney "strawberry tree" (*Arbutus*), and these are chiefly found in Devon, Cornwall, and south-west Ireland.

How these elements reached Britain was a problem of great complexity—a problem that must be solved by geologists, as it rests mainly upon the effect of the Glacial period upon the animals and plants, and the present distribution has been determined by two factors—the climatic changes, and geographical evolution.

In early Tertiary times Britain supported a tropical and subtropical life, but onwards a steady decline in temperature is indicated. The Pliocene period opened with a marine fauna of Mediterranean type, which was gradually replaced by a group of animals of "British" type, and this again by one of Arctic type. The Glacial period then ensued, and during that period the whole of the Northern Hemisphere experienced a very severe climate. The Alpine glaciers were then much bigger than now, while in north-western Europe a great ice-cap with an area of 2,000,000 square miles, having its centre in the present Baltic Sea, poured its ice over the Scandinavian heights, and across the North Sea. The whole of Scotland and Wales was buried in ice except for a few mountain summits, as was also nearly the whole of England and Ireland, while the only considerable parts of the country which were free from ice were the land to the south of the Thames, a narrow strip of southern Ireland, and isolated belts of the Pennine and Cleveland Hills.

In the Pliocene period England was connected with France by a broad isthmus across the east end of the Channel, but during the Glacial period the Straits of Dover were cut, probably by the overflow from a vast series of glacier-lakes lying to the northwards. Since that period the British Isles have undergone both elevation and depression, as is shown by the raised beaches and submerged forests, but such movements were not of sufficient amplitude to restore the land connection with the Continent, and had little, if any, effect upon the distribution of the fauna and flora.

Immediately before the Glacial period the flora of Britain was almost exclusively Arctic and included such forms as *Salix polaris* and *Betula nana*, but the fauna was not so conclusive, for in addition to the musk-ox, reindeer, Arctic fox, Siberian vole, and the lemming, there were the lion, hyæna, and hippopotamus. Migration, either annual or periodic, as has been suggested, did not explain this commingling of such widely different types. This latter group of animals was perhaps not so sensitive to cold as has been imagined, so long as food could be obtained the animals might survive even though a great change of climate took place. In the case of the herbivores their food would disappear with a change to Arctic conditions, and it is a striking fact that of the animals which have become extinct since the Glacial period, all, with one exception, are large herbivores.

To account for the animals and plants which have reached Britain since the Glacial period, it has been suggested that our islands have been sufficiently elevated to connect them with the Continent, but a reference to the Isle of Man will show that this is extremely improbable. The Isle of Man has a very diversified surface and soil, and the biological characteristics of an oceanic

island. It has a meagre flora with perhaps one endemic species, while the fauna has only a few mammals, most of which have evidently been introduced by man, no indigenous amphibia, only one reptile and no true fresh-water fishes except the trout. During glacial times the island was completely overridden by the Irish Sea ice-sheet, and thus there were no surviving fauna and flora—all that now exist having come in since that time. If the British Isles had all been subsequently joined to the Continent by the broad 100 fathom plateau, as some geologists have maintained, it is incredible that this island should have failed to get an abundant population.

How, then, did the animals and plants come that did not survive the Glacial period ? It seems quite certain that neither the Germanic not the Lusitanian element could have maintained itself in Britain under Arctic conditions—especially the Lusitanian, in view of the great delicacy of the fauna and flora, while in the very area which now yields their representatives in some abundance, we find a fossil flora with a high northern aspect. Hence they must have been subsequently introduced, and I see no improbability in Mr. Clement Reid's suggestion that the plants have been brought as seeds by chance agencies such as migrating birds and beasts, and I would extend a similar explanation to the Killarney slug. At the close of the Glacial period the Straits of Dover were probably not more than two miles wide, therefore the facilities for mammalian and bird migration were then much greater than at present, and many mammals could still have easily traversed the Straits. Such chance agents of transport have also played a large part in the repopulation of Ireland, and we see in its restricted fauna and flora, how precarious such casual modes of introduction must have been.

In conclusion, the evidence against a survival of the southern animals and plants through the Glacial period is very strong, as is that against the union of Britain with the Continent at a subsequent date. The only alternative is that such animals and plants as did not survive on the spot, have been introduced by chance agencies, and on this theory can be explained the relative poverty of the British fauna and flora in comparison with that of the Continent, and the greater prevalence of small-seeded plants in Britain,—such plants being better fitted for dispersal by wind and by birds.

REFERENCES :—

WRIGHT, "Man and the Glacial Period," Internat. Sc. Series.

GEIKIE.—"Great Ice Age," 3rd. ed.

DAWKINS.—"Early Man in Britain."

KENDALL.—"Glacial Geology of the Isle of Man" (Yn Lioar Manninagh).

REID.—"Origin of the British Flora."

SCHARFF.—"Origin of the European Fauna and Flora." Contemp. Sc. Series.

REFERENCES TO SUBJECTS OF OTHER PAPERS READ:

"A Geological Ramble along the Yorkshire Coast." Thos. Sheppard, F.G.S.

Sheppard.—"Geological Rambles in E. Yorks." 1903.

Phillips.—"Geology of the Yorkshire Coast." 1829.

Clement Reid.—"Geology of Holderness." 1885.

Tate and Blake.—"The Yorkshire Lias." 1876.

Mems. Geol. Survey.—"North Cleveland." 1888.

"Oolitic and Cretaceous Rocks South of Scarborough." 1880.

"Jurassic Rocks of Britain." 1892.

"Bridlington Bay."

"Scarborough and Flamborough Head."

"Whitby and Scarborough."

"The Coast Lines of Lancashire and Cheshire—their Forms and Origin." J. Lomas, A.R.C.S., F.G.S. (This paper is published in the Proc. Liverpool Geol. Soc., part ix., 1904.

"The Geology of the Lake District of South Perthshire." David Forsyth, M.A., D.Sc.

Annual Reports and Summaries of Progress of Geological Survey, from 1893 onwards.

Geikie.—"Scenery of Scotland." 1901.

THIRTY FIRST SESSION, 1904-1905.

Officers:

President: E. HAWKESWORTH.

Vice-President: DAVID FORSYTH, M.A., D.Sc.

Hon. Treasurer: S. W. CUTTRISS.

Hon. Secretary: W. PARSONS, F.R.G.S.

Hon. Librarian: JOSEPH LANG.

Members of Council:

J. E. BEDFORD, F.G.S.
GODFREY BINGLEY.
JNO. W. BOND.
F. W. BRANSON, F.I.C.
Rev. W. L. CARTER, M.A., F.G.S.
A. R. DWERRYHOUSE, M.Sc., F.G.S.
J. H. HOWARTH, J.P., F.G.S.
Prof. P. F. KENDALL, F.G.S.
Prof. G. R. THOMPSON, B.Sc., F.G.S.
C. T. WHITMELL, M.A., B.Sc.

ANNUAL REPORT.

Your Council has pleasure in reporting a very successful session, marked by an excellent series of papers, and a very gratifying attendance of members at the various meetings, of which eight have been held, as follows:—

1904.

Oct. 21—PRESIDENT'S ADDRESS:—"Notes on some Drift Deposits South and East of Leeds."

Exhibition of lantern slides illustrating the Geology of the Holderness Coast and Sedbergh. GODFREY BINGLEY.

Exhibition of maps, models, specimens, &c. Prof. P. F. KENDALL, F.G.S.

Nov. 18—"River Capture in Yorkshire." Rev. W. L. CARTER, M.A., F.G.S.

Exhibition of specimen of *Echinosphæra aurantium.* The PRESIDENT.

Dec. 16—"Geology at the British Association." Prof. P. F. KENDALL, F.G.S.

1905.

Jan. 20—"The Rocks which lie between the Carboniferous Limestone and the Millstone Grits in the Midlands, and their homotaxial equivalents elsewhere." WHEELTON HIND, M.D., F.G.S.

1905.
Feb. 17—"Critical Periods in the Earth's History." BEEBY THOMPSON, F.G.S.

Exhibition of a new crustacean and fossil plants from Lower Coal Measures, Dolly Lane, Leeds. JNO. W. BOND.

Exhibition of specimens of *Lepidodendron*, from Roundwood, Ossett. STANLEY NETTLETON.

Mar. 24—"The Eastern Extension of the Yorkshire Coalfield." Prof. P. F. KENDALL, F.G.S.

April 28—"Mineral Replacements and the Preservation of Organisms." A. R. DWERRYHOUSE, M.Sc., F.G.S. (*Illustrated by lantern slides and specimens.*)

May 19—ANNUAL MEETING.

"A Recent Geological Excursion in Lincolnshire." Prof. P. F. KENDALL, F.G.S.

According to a resolution of the Council the place of meeting has been changed from the Philosophical Hall to a more comfortable room in the Law Institute.

Your Council regrets to record the decease of Mr. John Ingleby and Mr. Rd. Crosland, both old and valued members of the Association, the former its President for 1892-4.

During the session 12 new members have joined the Association.

The thanks of the Association are due to the readers of papers, and to the University of Leeds for the use of rooms for two meetings.

The Balance Sheet shows a balance in hand of £5 11s. 6d.

"SOME DRIFT DEPOSITS NEAR LEEDS."

This Paper formed the substance of the Presidential Address delivered by Mr. EDWIN HAWKESWORTH, *October 21st*, 1904. *After being revised to date, it was published in the Proceedings of the Yorkshire Geological and Polytechnic Society, vol. xv., part* 3, 1905, *and is reprinted here by the kind permission of that Society, which has also lent the block of the map.*

On Sheet 78 of the Geological Survey one-inch map, between the rivers Aire and Calder, which unite about five miles to the south-east, are two patches indexed as "gravel, third river terrace." The northerly one, which may be termed, conveniently, the Rothwell Haigh patch, is roughly semi-circular in shape, and is separated from the southerly, or Oulton patch, which is of deltaic form, by a well-defined wide valley, through which flows the Oulton Beck. The size of the valley seems quite disproportionate to that of the present stream. The area of each patch is about a square mile, and their elevation varies from about 150 feet to 275 feet above O.D., but is mostly above 200 feet. The Aire near here is

about 50 feet and the Calder about 60 feet above O.D. The solid rocks of the area belong to the Middle Coal Measures, the Thornhill Rock, a thick sandstone, forming a prominent feature on the southern side of the Aire valley. The recent deposits are so variable in character, even in a short distance, as the following particulars will show, that it practically is impossible to give measured and detailed sections.

Previous Observations.

These deposits seem to have excited little attention from local geologists. The only available mention appears to be by the members of the Geological Survey.* It is only brief, and, after mentioning their position and elevation, it states "the probability seems to be that they are river gravels of considerable antiquity, formed when the river was flowing at the level on which they lie." Only one section was seen, and that in the Oulton patch, the contents of which were about 90 per cent. Coal Measure sandstones, with angular fragments of black or banded encrinital chert plentiful, also some large blocks and a few pebbles of Millstone Grit, and some angular and half-rounded blocks of calliard.

Messrs. Jowett and Muff† mention yellow boulder clay, 10 feet thick, with boulders of ganister, encrinital chert, and striated Millstone Grit, at Rothwell Haigh. Mr. Muff informed the writer this was exposed in making drains, and its relationship to the gravels was not noted.

Present Sections.

Rothwell Haigh patch.—Near the westerly edge an excavation was made in 1904 for a storage reservoir, above the 250 foot contour-line (see A on map). It exposed about 10 feet of varying sand and gravel, of yellowish colour, with intercalated beds of large stones, current-bedded in places, with traces of contortion in one place. Towards the upper part, especially at the northern end, the material became more clayey. Rock was not reached here, but other temporary excavations in the neighbourhood prove a thickness of quite 30 feet of similar material.

About 150 yards south-east of the previous section (see B on map) is a sandpit showing from 10 to 15 feet of yellowish sand and gravel, but the number and size of the contained stones is

* Geol. Survey Mem. Yorkshire Coalfield, 1878, p. 783.

† A. Jowett, M.Sc., and H. Brantwood Muff, B.A., F.G.S., "The Glaciation of Bradford, &c.," Proc. Yorks. Geol. and Polytec. Soc., vol. xv., part ii., p. 219, 1904.

not so large as at the reservoir, though they are so plentiful that all the sand has to be screened. To show the extreme variability of these deposits, this pit is now being worked in a westerly direction, exposing the following section :—

Very coarse gravel	2–3 feet
Sand, evenly bedded, practically free from stones	about 10 feet
Gravel	,, 1 foot
Large boulders resting on rock	,, 1 foot

In the sand are distinct incursions of rough, clean, angular white quartz grains, reminding one of broken-up coarse Millstone Grit, evidently not water transported for any considerable distance or time.

The finest and most interesting section in this patch is found in a large sand pit nearly opposite the John o' Gaunt Inn, and between the 200 and 225 feet contours (see C on map). At present it shows :—

Very coarse gravel or shingle ..	2–3 feet
Sand	about 15 feet
Very coarse gravel	10–12 feet
Sand	about 1 foot
Rough gravel, with large boulders,	thickness not known.

It may be possible before very long to obtain a view of the whole thickness of the deposit, and the character of the rock floor upon which it is laid. A few lenticular masses of clay occur in the sand, at times, but, at the south end of the pit, resting on rough gravel, a large mass of very fine stiff reddish clay was found, 2–3 feet thick in places. It was quite free from grains or pebbles of harder rock, and much of it was carted away for the purpose of puddling the adjacent reservoir. Above the clay was more coarse gravel.

About 300 yards east of the above section, the E. & W.Y.U. railway runs for some distance in a deep cutting through sandstone (Thornhill Rock). (See D on map.) This is overlaid by 10–20 feet of sands and gravels, which, though not very accessible, and now somewhat obscured, seem to be quite as variable in texture as in the other sections. They rest apparently on a flat surface of the sandstone, and it can be seen clearly how they cap the ridge dividing the Aire and Rothwell valleys. Running south, across the head of a small valley or depression, the railway cuts through a smaller thickness of the gravels.

Oulton patch.—Crossing the Rothwell valley, and passing through the ancient village of that name, the northern extremity of the Oulton patch is seen making a prominent feature in the landscape (Gravel Pit Wood, but no exposure now). About three-quarters of a mile south, near Royds Green, it attains its greatest elevation, 275 feet, this contour being formed roughly by a terrace-like spread of gravel. From here the ground gradually slopes away to the Calder valley.

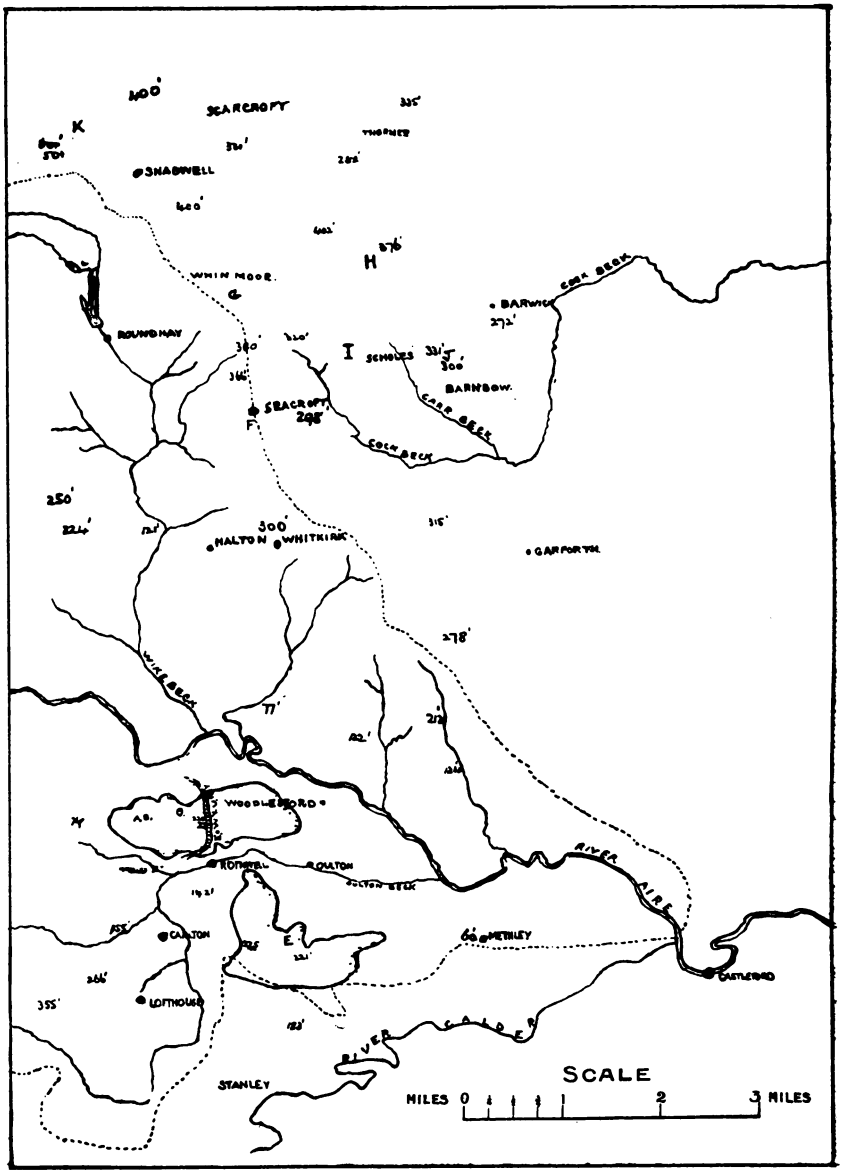
So far as can be ascertained, the only section now visible is in a gravel pit near the Home Farm, Oulton, just above the 200 foot contour (see E on map). It exposes quite 20 feet of coarse sandy gravel, without reaching solid rock. It is very full of pebbles and stones of all sizes, some pieces of sandstone being as much as 2 feet square, and quite angular. There is little evidence of bedding or arrangement, the stones, large and small, being scattered most irregularly throughout the mass. In the north-west corner the deposit becomes more sandy, with coaley bands, fewer stones, and is more clearly current-bedded.

The Contained Stones.

With one or two exceptions which further investigation may eliminate, both patches yield similar pebbles or boulders. The great majority are Coal Measure rocks—grits, sandstones, ganisters, and ironstone nodules. Millstone Grits and large quartz pebbles, probably derived from them, are present. There is a great number and variety of cherts, mostly in small squarish pieces, but with the angles sufficiently rounded off to indicate, in such a hard substance, that they have undergone considerable knocking about. Carboniferous Limestones are less common, leading one to infer that many of these must have been completely destroyed in the course of their journey from the source of origin. A fine piece of *Syringopora* with the matrix entirely dissolved out, was found in the John o' Gaunt section, from which also were taken a number of small very hard, and remarkably smooth rounded pebbles of fine grained crystalline, Carboniferous (?) Limestone, of quite a distinct character from any which have yet been noticed in the other sections. A few Silurian or Ordovician rocks have been found in both patches, but mostly at Oulton. No distinctly igneous rocks have been found, but one or two doubtful ones, one perhaps a quartz-porphyry, are awaiting microscopic examination.

Other Deposits to the Northward, between Aire and Wharfe.

Seacroft.—In making a manhole in connection with a sewer in 1904, about 250 feet above O.D., rounded boulders of ganister and sandstone were brought out (see F on map).



SKETCH MAP OF COUNTRY TO THE EAST OF LEEDS.

The gravel patches are outlined. The dotted line shows the boundary of the Aire watershed.

Whinmoor (See G on map.)—The Geological Suvey noted that over the country to the north of Leeds, great masses of drift occur, consisting mainly of stiff blue clay, containing amongst others mentioned, trap, flesh-coloured granite, and chalk. A bore hole at Whinmoor went through 114 feet of this stoney clay.*

Scholes.—Near here, in the cutting of the Leeds and Wetherby railway, between Scholes and Thorner, at over 350 feet above O.D., is a section of drift, in which have been noted, amongst others, cherts and grits.

At about same elevation, in Scholes, rounded boulders of very fine hard whitish sandstone were found in digging for foundations of a house (see I on map).

Cock and Carr Becks.—In many parts of these valleys, and adjacent, pebbles of sandstone, grit, ganister, and chert are abundant.

In other parts of this district traces of drift have been noted, as, for instance, in the fields north of Barnbow, about 300 feet above O.D. (see J on map), which are sprinkled with rounded pebbles of chert, sandstone, and ganister. At a higher elevation still, west of Scarcroft (see K on map), in making pipe trenches similar pebbles, with limestone in addition, were found.

Conclusion.

With the present available information, the writer is indisposed to generalise upon these observations, which are very detached, and somewhat obscure in some cases. The occurrence of real boulder-clay at Whinmoor and Rothwell Haigh seems to require further elucidation; especially does the presence of igneous rocks at the former locality.

It seems fairly certain that the Oulton and Rothwell Haigh deposits are not "river gravels of considerable antiquity," but these, taken in conjunction with the dispersal of pebbles and boulders very similar to those contained in them, between the Aire and the Wharfe, denote a period when the country between the Wharfe and Calder (if not further north and south), at all events east of Leeds, was covered with ice, or water, or most likely both in turn. However, the observations are now recorded, in the hope that in the near future they will be added to, and fit in with those of other workers in adjacent areas, thus making a complete chain of evidence, from which another chapter in the recent geological history of our county can be written.

* Geol. Surv. Mem. Yorks. Coalfield, 1878, p. 779.

"RIVER CAPTURE IN YORKSHIRE."

Abstract of Paper read by Rev. W. Lower Carter, M.A., F.G.S., *November 18th*, 1904.

River capture is the result of warfare between one stream and another. Certain rivers possess advantages over neighbouring streams in this contest. These advantages are mainly owing to (1) size of gathering ground; (2) slope of bed and therefore velocity; (3) softness of rocks over which the river flows.

From the first the Aire seems to have been the most powerful of the Yorkshire rivers, and, as a result, was instrumental in finally capturing the whole of the Yorkshire streams at present flowing into the Ouse. In the first cycle of the Yorkshire system, the rivers probably all flowed as consequent streams directly eastward to the sea. This was followed by a condition in which, as suggested by Mr. Cowper Reed, the present Tees drained out by the valley of the Esk. The present Swale may have been its most important feeder. The original course of the Ure was probably eastwards down the slope of the Wolds, and it was subsequently captured by a stream working backwards through the Coxwold-Gilling Gap, and entering the sea to the north of Filey. This, in turn, may have received the Nidd as a tributary, as the pre-glacial valley of the Nidd at Ripley bends northwards. The Wharfe probably flowed to the sea along the line of the Market Weighton Gap, whilst the Aire flowed directly east to the present Humber Gap. The Upper Aire shows interesting signs of being beheaded by the Ribble, which has carried off the head waters above Hellifield, leaving an unoccupied valley between that place and Gargrave.

Before the Glacial Period, the Tees and Swale systems seem to have been captured by a river working up from the present Tees mouth, and the Esk was thus left as a beheaded remnant, the Tees and the Swale subsequently being separated in glacial times. The Ure, Nidd, and Wharfe had now been captured by a feeder of the more powerful Aire, eating northwards along the belt of Trias, and the Rye thus was left as a beheaded remnant of the ancient Ure.

The advance of the ice-sheet in the Glacial Period dammed the valleys opening eastwards on to the coastline, and caused the formation of a series of glacier lakes, the overflows from which formed new channels, the most southerly of which was the Malton Gorge, by which Lake Pickering overflowed into the Ouse system. This circuitous route was rendered permanent by barriers of Drift, and caused the present roundabout course of the Yorkshire Derwent.

The southern set of Yorkshire rivers was then referred to, the history of the Don being dealt with at length. The author suggested that the Went might be the beheaded remnant of the ancient Calder, an elbow of capture being apparent at Wakefield,

and indications of an old connection between the Calder and the Went being afforded by the valleys at Sandal and Walton Parks. It was also suggested that the gap in the Wolds at Kirmington might be the continuation, glacially enlarged, of the ancient course of the Calder.

REFERENCES TO RIVER CAPTURE :—

JUKES.—Q.J.G.S., vol. xviii., 1862.

JUKES BROWNE.—Q.J.G.S., 1883, p. 596.

I. C. RUSSELL.—" River Development," 1898.

W. M. DAVIS.—" Geographical Journal," vol. v., 1895, p. 127.

COWPER REED.—" The Geological History of the Rivers of East Yorkshire." 1901.

W. LOWER CARTER.—B.A. Reports, Cambridge, 1904, p. 558. Proc. Yorks. Geol. Soc., vol. xv., part iii., pp. 388-410.

"THE EASTERN EXTENSION OF THE YORKSHIRE COALFIELD."

Abstract of Paper read by Professor P. F. KENDALL, M.Sc., F.G.S. *March 24th*, 1905.

The York, Derby, and Nottingham coalfield lies in a basin-fold of which the western edge and a small portion of the northern margin are exposed, the remainder of the basin and its edges being concealed beneath a discordant sheet of newer rocks, steadily increasing in thickness to the eastward by the successive on-coming of layer upon layer of eastwardly dipping beds.

The problem which has to be solved is the determination of the place and mode of uprise of the other edges of the coal-basin, beneath a mantle of newer rocks, hundreds or perhaps thousands of feet in thickness. The method adopted by the late Prof. Green, in his evidence to the last Commission, was to assume that the axis of the trough coincided with the position of the highest normal Coal Measure rocks in the visible field, and to draw an ellipse symmetrically about the edge of the elongated area in which they had been proved.

This, I believe, to be the foundation for the boundary adopted by the Commission.

Prof. Hull drew two lines upon the map which he presented, one defining the area within which the Coal Measures would be found within 2,000 feet of the surface, and an outer one marking what he supposed to be the actual limits of the basin. In his verbal evidence, however, Prof. Hull considerably enlarged his boundaries, and expressed the opinion that Coal Measures would be found at a depth of 4,000 feet " as far east as the escarpment of the chalk at the Humber." This more optimistic view is closely accordant with my own.

The principle which has been my guide throughout this enquiry is that which is chiefly associated in this country with the name of Mr. Godwin Austen, whose great services to the last Coal Commission are well known.

Mr. Godwin Austen argued that every undulation of the strata, whether trough-fold (syncline), or ridge-fold (anticline), was based vertically upon, and was a repetition of a fold which had affected older underlying rocks before the deposition of the superincumbent strata; and that, too, despite any levelling off to which the older rocks were subjected to by atmospheric or marine agents prior to the deposition of the later series.

Without committing myself to a plenary and unqualified acceptance of this doctrine, I am quite prepared to admit its general applicability, especially as in two cases, at least, I have found evidence on the borders of the York, Derby, and Nottingham Coalfield of a more convincing character than Godwin Austen was able to adduce.

The evidence of repetition of folding ("posthumous folding" of Suess) may take the form not merely of an arching of the rocks after deposition, but may manifest itself by the thinning of beds as they approach the axis of the fold, and by planes of erosion within the limits of a formation, as well as by actual gaps in the succession of the beds. Moreover, while some axes of unrest present evidences of movements repeated again and again through many successive periods, others exhibit unmistakeable signs of the renewal of the folding movement after long intervals of quiescence, or perhaps even of movements of the opposite sign; thus, in the last case, a fold of the arch type (anticline) may at some subsequent geological period sag downward and receive a quite abnormal amount of deposition, and later still may renew its arch-structure by the bending of the newer rocks.

A study of the country bounding the York, Derby, and Nottingham Coalfield, reveals three great posthumous folds, all of which (whatever their previous history) moved powerfully and with decisive effect, after the deposition of the Coal Measures, and before the Permian rocks were laid down.

As the arches rose the crests were worn off, and the Permian rocks were deposited on the eroded plane, sometimes thinning off against the flanks of the ridge as was the case with the Pennine arch and the Charnian fold, in other cases extending quite across the eroded arch as in the case of the very complex and disturbed region between the Yorkshire Coalfield and that of Durham.

The boundaries which I have drawn on the map are traced in each instance in relation to some considerable anticlinal fold, those on the north and the south-west are so patent, and the Coal Measures so clearly extend up to their margins so far as they can

be followed, that I feel a considerable degree of confidence in their validity. On the east the evidence is not nearly so complete, but I have drawn the line at the *first* anticlinal fold, indeed the only one between the coalfield and the sea, and have found corroboration in evidence of an entirely different character.

This boundary of the coalfield is not nearly so easy of definition as the northern and western, there is no outcrop of ancient rocks to aid, nor are there at present any borings of sufficient depth to throw a clear light on this obscure problem.

The chief evidence is found in an anticlinal fold in East Lincolnshire, which was discovered by the evidence of two boreholes subsequent to the completion of the geological survey of the district. This anticline, which affects the chalk and Lower Cretaceous rocks, runs in a north-westerly direction from the neighbourhood of the Wash, through Willoughby and Alford, up to Louth, beyond which it has not been traced, nor do I think it is traceable as a disturbance of the chalk.

The question must now be considered :—Is this a posthumous fold repeated after a long interval of geological time, upon the crest of a deep-seated fold which had affected the Carboniferous rocks ?

A close analysis of the details of borings through the Secondary rocks reveals no tendency in them to thin out or disappear by unconformity in approaching this line ; on the contrary, such evidence as is obtainable points to the directly opposite opinion, the Secondary rocks seem to swell out in that direction.

This, however, is not decisive,—the Wealden anticline in the South of England, and the Cleveland anticline in the north, are both folds affecting the Chalk, and both appear to be reared upon pre-Permian folds (the Cleveland arch certainly is), yet both regions are areas in which Jurassic and Cretaceous rocks attained an immense development. This testimony seems quite indecisive, but there are two facts which induce me to believe that the Willoughby anticline is the true boundary of the coalfield. The Coal Measures up to the eastern edge of the visible field are persistently dipping eastward, the boring at Haxey (South Carr) shows, however, that not only is the thickness of Coal Measures above the Barnsley Bed less than it is in the pits on the same parallel further west, but also that the strata are " absolutely flat," or, in other words, are rising eastward relatively to the Permian rocks which cover them.

This may be quite a local arrangement, but, if not, it proves that Haxey lies to the eastward of the axis of the trough in which the Coal Measures lie. Further corroboration is furnished by the magnetic survey of Messrs. Thorpe and Rücker, which indicates a belt of high magnetic deviation coinciding closely with the direction of the Willoughby anticline. None of the evidence can be regarded as convincing if taken by itself, but I think that there is some cumulative value in the three distinct classes of testimony.

The chief practical importance of the demonstration is this: If the fold is a posthumous one, mining operations would cease in an easterly direction in consequence of the rising of the Coal Measures against an axis of older rocks, while if it be not a posthumous fold mining would cease at about the same line by the descent of the Measures below the limit (4,000 feet) at which coal-working would be practicable or profitable. The question may perhaps find a decisive answer from a boring which is now being put down at South Cockerington, near Louth. I should have preferred a site west of the anticline rather than east of it, as more likely on any hypothesis to meet coal at a moderate depth; all the same it is a bold and apparently well-directed attempt deserving of success.

It will be observed that I have drawn my boundary line about six miles from the axis of the anticline, that was to allow room for a belt of Lower Carboniferous rocks, without any covering of Coal Measures on the crown of the fold as we find to be the case with the Pennine Chain. The caution may be superfluous, for the Lincolnshire anticline is neither very broad nor very high.

REFERENCE:—Final Report of the Royal Commission on Coal Supplies. Part ix. Report of the Geological Committee. (Wyman & Sons, 2/-.)

MAP SHEWING THE ESTIMATED EASTERLY EXTENSION OF THE YORKSHIRE COALFIELD.

(Block kindly lent by the Editors of "The Naturalist.")

REFERENCES TO SUBJECTS OF OTHER PAPERS READ:

"THE ROCKS WHICH LIE BETWEEN THE CARBONIFEROUS LIMESTONE AND THE MILLSTONE GRITS IN THE MIDLANDS, AND THEIR HOMOTAXIAL EQUIVALENTS ELSEWHERE." WHEELTON HIND, M.D., F.G.S.

HIND AND HOWE.—"THE PENDLESIDE GROUP AT PENDLE HILL." Q.J.G.S., vol. lvii., 1901.

HIND.—"THE CHARACTERS OF THE CARBONIFEROUS ROCKS OF THE PENNINE SYSTEM." Proc. Yorks. Geol. and Polyt. Soc., vol. xiv., part 3, 1902.

DR. W. HIND.—"THE SUBDIVISIONS OF THE CARB. SERIES IN GREAT BRITAIN, &c." Proc. Edinburgh Geol. Soc., 1898.

HIND AND STOBBS.—"THE CARBONIFEROUS SUCCESSION BELOW THE COAL MEASURES IN NORTH WALES." Geological Magazine, Sept., Oct., and Nov., 1906.

"CRITICAL PERIODS IN THE EARTH'S HISTORY." BEEBY THOMPSON, F.G.S.

W. J. SOLLAS.—"AGE OF THE EARTH AND OTHER ESSAYS."

"REPORT OF THE MAGNESIAN LIMESTONE COMMITTEE."

By A. R. DWERRYHOUSE, D.Sc., F.G.S.

In 1900 a Committee was formed to investigate the Magnesian Limestone and associated rocks of Permian age in the neighbourhood of Leeds.

The first field meeting of the Committee was held at Micklefield for the investigation of the Magnesian Limestone exposed in the extensive quarries there.

The dip at the end of the quarry nearest to Peckfield Colliery is 4° in the direction N., 70° E.

At the south end of the quarry the section is as follows :—

	Ft	In.
Red Soil	1	6
Granular Sandy Limestone	7	0
Marl	—	7
Limestone	2	0
Ripple Marked Surface	—	0
Limestone	20	0 (+)

Portions of the limestone in the neighbourhood of the ripple-marked surface show a distinctly brecciated structure, indicating shallow water conditions accompanied by contemporaneous erosion.

The joints run S. 45° W., and are in some cases slickensided horizontally.

In the following year (1901) the investigations were continued in the neighbourhood of Kiddal Hall.

The Hall is built on the Millstone Grit on the north side of the York Road, between Seacroft and Tadcaster, and lies immediately to the north of the great boundary fault of the Yorkshire Coal Field.

The fault is in part at least of post Permian age, as immediately across the road from the Hall the Magnesian Limestone is seen in a quarry at a lower level than the Millstone Grit.

The Magnesian Limestone here cannot be very thick, as the quarry is close to the edge of the outcrop. In the quarry 18 feet of limestone are exposed but the base is not visible. The limestone is thin-bedded, and contains several brecciated layers. The dip is 2° to 3°—N. 50° W. Dendritic crystals of Pyrolusite (Manganese dioxide) are common along the joints in the limestone.

Beneath the escarpment near the York Road a Coal Measure sandstone is exposed in the bed of a small stream. This sandstone has been let down to its present position in juxtaposition to the Millstone Grit by the boundary fault previously mentioned.

Excursion to Garforth.

The Magnesian Limestone in this neighbourhood forms a bold escarpment overlooking the undulating ground of the Yorkshire Coal Field to the west. The escarpment runs approximately N. and S., but there are numerous promontories and outliers.

In a small quarry in plantation 200 yards south-west of Stub Wood, a sandy limestone is exposed, three or four feet only being visible, the remainder being obscured by vegetation and spoil heaps. This represents the basement beds, and is close to the foot of the escarpment.

Two hundred yards south of Stub Wood is another quarry in the limestone. The rock is thin-bedded, and of the usual cream colour. Specimens of *Schizodus obscurus* were collected here, though they are by no means plentiful.

All along the escarpment from the North Eastern Railway at Garforth as far south as Pontefract, the Magnesian Limestone rests on a bed of sand, sometimes accompanied by thin beds of white or greenish marl.

These basement sands vary considerably in thickness, and are remarkable for the quantity of Kaolin disseminated through them. They appear to occur in detached basins, and often contain fragments of the underlying rocks. Thus the sands are absent at Throstle Nest near Parlington Hall, appearing immediately to the south of the North Eastern Railway at Garforth. They thicken towards the south, while to the south of Pontefract they again die out. At Knaresboro' again there is in the Castle Hill section a considerable thickness of sand, at the base of the limestone.

The Kaolin appears to have been deposited as such, and not to be the result of the decomposition of Felspar grains in the sand. It is distributed evenly throughout the whole mass, and does not occur in pockets, or in aggregations, as in the well-known case of the

Millstone Grit. There is no secondary crystallisation of the quartz grains, and as a general rule the sand is quite loose, to which it owes its local name of "quicksand." In parts, however, the sand is cemented by Calcite, and shows lustre-mottling.

It is suggested that the deposition of the Kaolin was in progress from still muddy water, while from time to time sand was blown on to the surface of the water, otherwise it is difficult to understand how coarse sand and fine clay could be deposited simultaneously at the same point.

The sands are well seen in the Garforth Cliff Quarry, where there is also a sand mine which is worked below the limestone escarpment, the face of which has been quarried back for some distance.

The section in the quarry is as follows :—

	Ft.	In.
Soil	—	6
Thin-bedded Limestone	10	0
Massive Limestone	1	2
Platy Sandstone	—	0½
Hard Calcareous Sandstone	—	3
Yellow Sand with Kaolin	5	0 (+)

At the mouth of the mine the sand is from 8 to 9 feet thick. It is strongly current-bedded, and contains less Kaolin than is usually the case.

The sands rest unconformably on the red and grey shales of the Coal Measures, the unconformity being well seen in the cutting leading to the mine.

Excursion to Garforth and Kippax.

Peckfield House Quarry was examined. It is excavated in thin-bedded cream-coloured limestone and is 20 feet deep. It has not been worked for many years, and some of the sections are overgrown by vegetation.

The dip is in a north-easterly direction, and is about 2 .

In the village of Kippax, opposite the Board School, is an exposure of the limestone showing a dip of 10° in the direction N. 10° E.

At White Hills, Kippax, is a very extensive series of quarries at several different levels, and here very fine sections both of the limestone and of the basement beds are to be seen.

The basement beds consist of sandstone, which in its upper portion contains brecciated bands made up of angular fragments of limestone and small pebbles of Coal Measure Sandstone, and small nodules of Calcite.

The section in the lower range of quarries may be generalised as follows :—

	Ft.	In.
Thin-bedded Limestone with sand partings	18	0
Hard Sandstone with brecciated bands at the top	6	0 (+)

In the upper range of quarries the limestones are more massive but are much broken up by joints which have been widened by solution. Upwards of 30 feet of limestone are exposed in these quarries.

Excursion to Pontefract.

The town of Pontefract stands on an outlier of Magnesian Limestone, with its accompanying Basement Sands, the whole resting unconformably on the Coal Measures.

The sand has been mined in many places below the town, and the following section is exposed in one of the old workings :—

	Ft.	In.
Thin-bedded Limestone	4	0
Current-bedded Sandstone	5	0
Current-bedded Yellow Sand	10	0 (+)

Close to this is another section showing 18 feet of sand with limestone above.

In Cobbler Quarry, Pontefract, 30 feet of very cavernous Magnesian Limestone is exposed. There are in these beds many hollow nodules of Dolomite often containing Rhombohedra with curved faces and edges.

Specimens of *Bakewellia antiqua* were collected here in considerable numbers.

A new working has recently been opened in the basement sands on the main road near the old turnpike east of Pontefract station. The section is 10 feet deep, and the base of the sand is not exposed. The sands are current-bedded, and this bedding shows ripple marks.

The ripples all have their steep sides towards the West, and have been produced on a highly inclined surface. They are therefore in all probability wind ripples.

Colouring due to infiltration is to be seen in this cutting, the bands of colour crossing both the true and current bedding.

In Fairy Hill Lane, Pontefract, 45 feet of cream-coloured Magnesian Limestone, containing many geodes with Calcite and Dolomite crystals, is exposed in a long quarry. The dip is 2° to the south-east. No fossils were observed in this quarry.

The sign (+) after the thickness of any bed indicates that its base was not exposed and that its thickness, though unknown, is greater than the figures given.

The directions have all been corrected for magnetic declination.

List of Members at end of Session, 1905-6.

Those who have contributed Papers or conducted Excursions are distinguished by an asterisk.*

Year of Election.

HONORARY MEMBERS.

1886 *Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, near York.
1886 *Horne, Wm., F.G.S., Leyburn.
1891 *Marr, J. E., D.Sc., F.R.S., Cambridge.
1874 *Miall, Prof. L. C., F.R.S., F.G.S., F.L.S., The University, Leeds.
1887 *Sollas, Prof. W. J., D.Sc., F.G.S., Oxford.
1890 *Woodward, A. Smith, LL.D., F.R.S., British Museum (Natural History), London.
1896 *Groom, Prof. T. T., M.A., D.Sc., The University, Birmingham.

ORDINARY MEMBERS.

1904 Abbott, A., North Terrace, Bramley.
1891 Bailey, J. W., 2, St. Mark's Villas, Leeds.
1897 Bain, J., The Bracken, Ilkley.
1899 Barnett, R. E., B.Sc., 9, Virginia Road, Leeds.
1904 Beahan, J. J., City Engineer's Office, Leeds.
1882 *Bedford, J. E., F.G.S., Arncliffe, Shire Oak Road, Leeds (*Member of Council*).
1889 *Bingley, Godfrey, Thorniehurst, Shaw Lane, Leeds (*Member of Council*).
1895 Bees, W. J., B.Sc., 43, Ash Grove, Leeds.
1883 *Branson, F. W., F.I.C., 14, Commercial Street, Leeds (*Member of Council*).
1883 *Brownridge, Chas., F.G.S., M.Inst.C.E., 26, North Road, Birkenhead (*Past President*).
1904 *Burnet, Arthur, 52, Prospect Terrace, Hunslet, Leeds (*Member of Council*).
1889 *Carter, Rev. W. Lower, M.A., F.G.S., Birkenhead (*Member of Council*).
1904 Chadwick, K. M., "Lauriston," Leeds Road, Harrogate.
1906 Cheetham, C. A., "Glenmore," Armley, Leeds.
1905 Charlesworth, A., M.Sc., Cockburn High School, Leeds.
1891 *Clough, S., Micklefield.
1886 Crowther, J. A., Borough Engineer, Southampton.
1890 *Cuttriss, S. W., M.I.C.E., Prudential Buildings, Leeds (*Hon. Treasurer*).
1896 Dodgson, Aquila, "South Lea," Kirkstall Lane, Leeds.
1896 *Dwerryhouse, A. R., D.Sc., F.G.S., "Glyn Garth," Weetwood Lane, Leeds (*President*).

1904 Edwards, E. J., M.Sc., 12, Norwood Terrace, Leeds (*Hon. Secretary*).
1905 Everett, J. H., B.Sc., Cockburn High School, Leeds.
1891 *Forsyth, David, M.A., D.Sc., 101, Caledonian Road, Leeds (*Member of Council*).
1893 Hanbury, Chas., 1, Park Place, Leeds.
1901 Hastings, Geoffrey, 15, Oak Lane, Bradford.
1886 *Hawkesworth, Edwin, "Sunnyside," Crossgates, Leeds (*Hon. Secretary*).
1890 Heaton, Hy., Cot Field, Roundhay, Leeds.
1887 Hewson, T., M.I.C.E., Barkston Lodge, Roundhay, Leeds.
1889 Hewson, T., Junr., "Park Cottage," Roundhay, Leeds.
1905 Higginbottom, J., Rain Road, Morley.
1885 Hill, John, J.P., Gladstone Terrace, Morley.
1875 *Holgate, Benjn., F.G.S., "The Briers," Roundhay, Leeds (*Past President*).
1906 Holgate, T. P., B.Sc., 28, Methley Mount, Chapel Allerton, Leeds.
1905 Hornby, John, St. Jude's School, Hunslet, Leeds.
1889 *Howarth, J. H., J.P., F.G.S., Somerley, Halifax (*Member of Council*).
1904 Howatson, E. H., City Engineer's Office, Leeds.
1886 Kay, Stanley R., 40, Sholebroke Avenue, Leeds.
1891 *Kendall, Prof. P. F., M.Sc., F.G.S., 5, Woodland Terrace, Chapel Allerton, Leeds (*Member of Council*).
1893 Kendall, Mrs. P. F., 5, Woodland Terrace, Chapel Allerton, Leeds.
1893 Kirk, A. E., Buckingham Villas, Leeds.
1906 Keighley, L., Globe Road, Leeds.
1893 *Lang, Joseph, 8, Roundhay Place, Harehills Lane, Leeds (*Hon. Librarian*).
1900 *Lupton, Arnold, M.P., 6, De Grey Road, Leeds.
1905 Mackenzie, A. H., M.A., B.Sc., 25, Estcourt Avenue, Headingley, Leeds.
1889 Mitchell, F., 9, Upper Fountaine Street, Leeds.
1884 Nettleton, Hugh, Borough Engineer, Weston-Super-Mare.
1903 *Nettleton, Stanley, Roundwood, Ossett.
1904 Owen, H. A., City Engineer's Office, Leeds.
1895 *Parsons, W., F.R.G.S., Woodlands View, Horsforth, Leeds (*Vice-President*).
1892 Pawson, A. H., J.P., F.L.S., F.G.S., Artillery Mansions, Victoria Street, London, S.W.
1874 *Pocklington, H., F.R.M.S., 41, Virginia Road, Leeds.
1902 Price, A., 16, Northfield Terrace, Eastmoor Road, Wakefield.
1885 Ripon, The Most Hon. The Marquis of, K.G., Studley Royal, Ripon.
1881 Roebuck, W. Denison, F.L.S., 259, Hyde Park Road, Leeds.
1887 *Rowley, Walter, F.G.S., F.S.A., Alder Hill, Meanwood, Leeds.
1904 Robinson, W. J., 54, Cardigan Lane, Leeds.
1905 Smith, W. F., Waterworks Engineer's Office, Leeds.

1905 Smith, H., 52, Wellclose Mount, Leeds.

1887 Stephenson, J., Brownberries Manor, Horsforth.

1890 Stephenson, W. E., A.M.I.C.E., Brownberries Manor, Horsforth (*Member of Council*).

1906 Sunderland, Wm., City Engineer's Office, Leeds.

1902 *Thompson, Prof. G. R., B.Sc., F.G.S., 5, Shaftesbury Avenue, Roundhay, Leeds (*Member of Council*).

1906 Thornber, W., Oxford Chambers, Victoria Square, Leeds.

1906 Turner, F., 34, Wesley Street, Morley.

1904 Varey, J. A., City Engineer's Office, Leeds.

1904 Walbank, Wm., "Pickom Lodge," Halton, Leeds.

1897 *Whitmell, C. T., M.A., B.Sc., "Invermay," Hyde Park, Leeds (*Member of Council*).

1905 Whitmell, Mrs. C. T., "Invermay," Hyde Park, Leeds.

1903 Wilcock, P. F., Hollyshaw Lane, Whitkirk, Leeds.

1905 Wilkinson, G. E., 12, Methley Mount, Chapel Allerton, Leeds.

1889 Wilkinson, J. J., Burnside, Skipton.

1891 Witts, J. W., City Engineer's Office, Leeds.

ASSOCIATE MEMBER.

1894 Bond, J. W., Torre Road, Burmantofts, Leeds (*Member of Council*).

Members changing their address are requested to notify the Secretaries at once.

OFFICERS, 1906-7.

President :

A. R. DWERRYHOUSE, D.Sc., F.G.S.

Vice-President :

W. PARSONS, F.R.G.S.

Hon. Treasurer :

S. W. CUTTRISS, Prudential Buildings, Leeds.

Hon. Secretaries :

E. J. EDWARDS, M.Sc., 12, Norwood Terrace, Leeds.

E. HAWKESWORTH, Sunnyside, Crossgates, Leeds.

(All correspondence to be addressed to the latter.)

Hon. Librarian :

JOSEPH LANG, 8, Roundhay Place, Leeds.

Members of Council :

GODFREY BINGLEY.

ARTHUR BURNET.

F. W. BRANSON, F.I.C.

Rev. W. L. CARTER, M.A., F.G.S.

J. H. EVERETT, B.Sc.

D. FORSYTH, M.A., D.Sc.

J. H. HOWARTH, J.P., F.G.S

Prof. P. F. KENDALL, M.Sc., F.G.S.

W. E. STEPHENSON, A.M.I.C.E.

H. SMITH.

Prof. G. R. THOMPSON, B.Sc., F.G.S.

C. T. WHITMELL, M.A., B.Sc.

Leeds Geological Association.

THE OBJECT OF THIS SOCIETY is to promote the study of Geology by means of field excursions, exhibitions of specimens, reading of original papers, and discussions. Anyone in any degree interested in the above will be warmly welcomed on attending.

MEETINGS are held usually on the third **Friday** evening in each month, from October to May, at **7.30,** in the **Library, Law Institute, Albion Street, Leeds.** Members are notified by post of each meeting.

EXCURSIONS are made frequently to places of geological interest.

YORKSHIRE NATURALISTS' UNION.—Members have the title and privileges of Associates of this Union (the Association being affiliated with it), and are entitled to attend all its meetings and excursions.

SUBSCRIPTION, 5s. per annum, payable in advance, on July 1st in each year. Members who reside more than twenty miles from Leeds, **2s. 6d.** per annum.

Members changing address are requested to at once notify the Hon. Secretaries, who will also be pleased to receive the names of any ladies or gentlemen desiring to join the Association.

E. J. EDWARDS, M.Sc., } *Hon Secs.*
E. HAWKESWORTH, }
Sunnyside, Crossgates, Leeds.

CONTENTS.

	Page.
Preface	4
Report, 1900-1901	5
The Airedale Glacier—Muff	6
Geology of Ingleborough—Howarth	7-1[illegible]
References to other Papers, 1900-1901...	1[illegible]
Report, 1901-1902	14-1[illegible]
Aims of a Local Geological Society—Forsyth	15-1[illegible]
References to other Papers, 1901-1902...	[illegible]
Report, 1902-1903	18-1[illegible]
Causes of Volcanic Action—Forsyth	19-[illegible]
Geological Photography—Bingley	22-[illegible]
Underground Waters of Ingleborough—Dwerryhouse	[illegible]
Glacier Lakes in Cleveland Hills—Kendall	23-[illegible]
Report, 1903-1904	25-[illegible]
Geology and Vegetation of West Riding—Smith	26-[illegible]
Origin of British Fauna and Flora—Kendall	29-[illegible]
References to other Papers, 1903-1904...	[illegible]
Report, 1904-1905	33-[illegible]
Some Drift Deposits near Leeds—Hawkesworth	34-[illegible]
River Capture in Yorkshire—Carter	40-[illegible]
Eastern Extension of Yorkshire Coalfield—Kendall	41-[illegible]
References to other Papers, 1904-1905...	[illegible]
Report of Magnesian Limestone Committee—Dwerryhouse ...	45-[illegible]
List of Members	49-[illegible]
Officers 1906-1907	[illegible]

Science Library
QE
1
.L48
v.3
pt. 15

Transactions

OF THE

Leeds Geological Association.

PART XV.

1908-9 | 1909-10

(Also Issued in Monthly Numbers)

PRICE TWO SHILLINGS

(Members only purchase at a reduced price on being published Annually)

UNIVERSITY OF MICHIGAN LIBRARIES

THE TRANSACTIONS OF THE LEEDS GEOLOGICAL ASSOCIATION.

PART XV.

1908–9. | 1909-10.

EDITED BY THE HONORARY SECRETARY.

LEEDS.
Nutt & Co., Ltd., Printers.

Issued October 12th, 1910.

Science Library
QE
1
.L48
v.3
pt.15

CONTENTS.

	PAGE
Annual Report, 1908–9	5
Radio-active Elements and Geology—Branson	8
Recent Deposits in Airedale—Teale and Hawkesworth	9
Some Boulder-like Masses in Fireclay, near Kilnhurst—Hawkesworth (*with plate*)	17
The Applications of Geology to Public Works Construction—H. Lapworth	18
Geological and Biological Changes at close of Cretaceous Period—Kendall	20
The Glacial History of Holderness—Sheppard	21
References to the subjects of other papers read	23
Annual Report, 1909–10	24
The Origin of Lakes—Whitmell	27
Cannel and its Affinities—Nettleton (*with section*)	30
Fossil Plants—Hemingway	33
The Origin of the Trias—Kendall	36
Reef Knolls—E. Parsons	38
Note on a Section in Meanwood Ganister Quarry—Gilligan (*with plate*)	40
Report of Excursion to Otley	41
" " Grassington and Thorpe	41
" " Clapham	41
" " Whitwood	43
" " Fryston	43
" " Woodlesford	43
" " Meanwood	44
" " Ingleton	44
" " Sedbergh	44
The Library	45
Balance Sheet, 1909–10	46
List of Members	47
Officers, 1910–11	51
Price list of back parts of Transactions	51
Terms of Membership, etc.	*Inside of back of cover.*

Thirty-Fifth Session, 1908-9.

Officers:

President: F. W. BRANSON, F.I.C.

Vice-President: A. R. DWERRYHOUSE, D.Sc., F.G.S.

Hon. Secretary and Treasurer: E. HAWKESWORTH, Sunnyside, Cross Gates, Leeds.

Members of the Council:

GODFREY BINGLEY.
ARTHUR BURNET.
A. CHARLESWORTH, M.Sc.
C. A. CHEETHAM.
J. H. EVERETT, B.Sc.
S. W. CUTTRISS, M.I.E.E.
D. FORSYTH, M.A., D.Sc.
A. GILLIGAN, B.Sc.
Prof. P. F. KENDALL, M.Sc., F.G.S.
STANLEY NETTLETON.
W. PARSONS, F.R.G.S.
HY. SMITH, F.I.P.S.
Prof. G. R. THOMPSON, B.Sc., F.G.S.
C. T. WHITMELL, M.A., B.Sc.

ANNUAL REPORT.

It is again the pleasant duty of your Council to report a successful session. The membership shows a further increase, the meetings and excursions have been well attended, and the papers read, several of them being accounts of original work, have been of great value and interest.

MEETINGS.—Eight Evening Meetings have been held as follows :—

1908.

Oct. 16—Opening Meeting of the Session.

PRESIDENT'S ADDRESS : "Radio-active Elements and Geology." (*Illustrated by experiments*).

Exhibition of Specimens :—A collection of fossil plants from the Lower Oolitic Sandstones of Marske and Whitby, along with specimens of recent allied species ; saurian remains from Whitby ; a specimen of the recently discovered foot-prints from the Lower Oolite, Whitby ; the latest maps and memoirs of the Geological Survey ; sections of Coal Measure plants displayed under microscopes, etc., etc. THE MEMBERS OF THE GEOLOGICAL STAFF OF THE UNIVERSITY

A complete colony of coral from the Lower Carboniferous, Norber Brow ; fish remains from the "Red Beds," Carboniferous, Richmond, Yorks. ; *Trinucleus*, from the Bala Beds, Norber. E. HAWKESWORTH.

Nov. 20—Address by PROFESSOR KENDALL, M.Sc., F.G.S., on "The Geological and Biological Changes at the Close of the Cretaceous Period." (*Illustrated by lantern slides*).

Dec. 18—Address by A. R. DWERRYHOUSE, D.Sc., F.G.S. "Geology at the British Association, Dublin, 1908."

1909.

Jan. 15—"Extracts from a paper on "The Aire Valley Deposit," written by the late T. P. Teale, F.R.S., in 1854, with notes thereupon. E. HAWKESWORTH.

"Note on a Section at Kilnhurst." (*Illustrated by photographs and specimens*). E. HAWKESWORTH.

Exhibition of lantern slides, showing sections and views at the Leeds new filter beds, Otley Road; Hawksworth quarries; Richmond district; and the Berwyns. GODFREY BINGLEY.

Feb. 26—"The Occurrence and Mining of Tin Ores." (*Illustrated by lantern slides, maps, and a collection of specimens*). STANLEY NETTLETON.

"'Marine Bands in the Millstone Grit of Wharfedale." (*Illustrated by a section, and a collection of fossils*). G. V. WILSON, B.Sc.

Inspection of the New Mining Department of the University.

Mar. 19—Lecture by H. LAPWORTH, D.Sc., F.G.S., A.M.I.C.E., "The Application of Geology to Public Works Construction." (*Illustrated by diagrams and lantern slides*).

April 30—Lecture by THOS. SHEPPARD, F.G.S., "The Glacial History of Holderness." (*Illustrated by lantern slides*).

May 21—ANNUAL MEETING. Annual Report and Balance Sheet, election of Officers, etc.

"Some effects of the Cloud-burst of June, 1908, in Wharfedale." (*With lantern illustrations*). A. GILLIGAN, B.Sc.

"A communication regarding some Sections in Davies' Exploring Heading, Whitwood Collieries." (*Illustrated by sections*). E. L. HUMMEL, B.Sc.

The average attendance at these Meetings has been about 35.

SPECIAL MEETINGS.—On October 19th, several members accepted the invitation of the Leeds Naturalists' Club, to attend its opening meeting.

The following evening a large number of the members had the privilege of attending a demonstration of "Lumiére's Natural Colour Photography," by invitation of the Leeds Photographic Society.

The President of the Leeds Philosophical and Literary Society (E. Kitson Clark, Esq., M.A., F.S.A.), invited the Association to attend a lecture on January 19th, by Dr. Edward A. Wilson, of the "Discovery Antarctic Expedition, 1901–4, on 'Ice.'" Dr. Wilson being prevented from fulfilling his engagement, owing to illness, his place was taken by Professor Kendall, who lectured on "Early Man." The invitation was repeated for February 16th, when Dr. Wilson was able to deliver his lecture. A strong contingent of our members attended on both occasions.

On January 22nd, February 5th and 12th, and March 12th, a special course of four lectures on "The Interpretation and Use of Geological Maps," was given by Dr. Dwerryhouse. The number of members (11) attending was not as large as anticipated, but those who availed themselves of the course derived great pleasure and instruction from it. After the concluding lecture, a very hearty vote of thanks was accorded Dr. Dwerryhouse.

EXCURSIONS.—The following have taken place :—

1908.
May 16—Topcliffe (Y.N.U.) Lias and Glacial.
,, 23—Halifax—Millstone Grit and Lower Coal Measures. Leader: MR. WM. FIELDING.
June 3—(Evening) Messrs. J. & C. Boyle's Brickworks, Leeds. Lower Coal Measures.
,, 6—Hornsea (Y.N.U.) Glacial and Post-Glacial.
,, 17—(Evening) Otley. Carboniferous. Leader: MR. G. V. WILSON, B.Sc.
July 11—Grassington and Thorpe. Carboniferous and Recent. Leaders: A. GILLIGAN, B.Sc., and G. V. WILSON, B.Sc.
Aug. 1—(Y.N.U.) Osmotherley. Jurassic and Glacial.
Sep. 5—(Y.N.U.) Clapham. Pre-Carboniferous and Carboniferous. Leader: PROFESSOR T. MCKENNY HUGHES, M.A., F.R.S.
Oct. 3—Whitwood Collieries. Leader: E. L. HUMMEL, B.Sc.

1909
April 24—Fryston, Carboniferous and Permian. Leader: STANLEY NETTLETON.

Our own excursions were fairly well attended, and the Association was well represented at most of those of the Y.N.U.

LIBRARY.—The publications of various societies and institutions have been received, also by the kindness of Mr. Arnold Lupton, M.P., the Q.J.G.S., as published.

TRANSACTIONS.—Part 14 has been issued. Besides having a classified index of all the parts, it contained a description of the Coal Measures of Leeds, by Mr. Benjamin Holgate, F.G.S., illustrated by a series of six plates, the blocks for which were very kindly presented by the President. The sale of back parts has realised £1 9s. 6d.

MEMBERSHIP.—During the session, 9 new members, 10 associates and 2 country members have been elected. Two associates have become members, one member an associate, and one ordinary member a country member. Eight members and 4 associates have resigned.

There are now on the roll :—8 Honorary Members, 79 Ordinary Members, 10 Country Members, 21 Associates, a total of 118, showing a net increase of 6 over the previous session.

COUNCIL.—There have been four Meetings of the Council, with an average attendance of 10.

In conclusion your Council desires to express the sincere thanks of the Association to the readers of papers, and those who have exhibited specimens or lantern slides at the meetings ; to the leaders of excursions ; to the Leeds Naturalists' Club, the Leeds Photographic Society, and the President of the Leeds Literary and Philosophical Society, for invitations to attend some of their meetings ; to Mr. Arnold Lupton, M.P., for his gift of the Q.J.G.S. ; to Dr. Dwerryhouse, for his special course of lectures ; to the President, for his generous gift of the blocks for the plates in the Transactions, and to Mr. Holgate for his description of them ; to other donors to the Library ; and to the members of the staff of the Geological Department of the University, whose assistance in many ways has added materially to the success of the Association.

"RADIO-ACTIVE ELEMENTS AND GEOLOGY."

Abstract of Presidential Address delivered by MR. F. W. BRANSON, F.I.C., F.C.S., *October 16th*, 1908.

Radio-activity is due to atomic disintegration. To take a familiar example, radium, which behaves in every respect as an element, gradually becomes, by atomic changes, resolved into helium. During these changes a considerable amount of heat is liberated, and electrically charged corpuscles are given off capable of passing through solid bodies owing to their great velocity and infra-atomic size. The newly discovered phenomenon is universally present in all rocks, and in the waters of all rivers and seas. The amount, however, is unequally distributed. Thus, sea water contains a larger proportion of radio-active substances than river water, due to the fact that, as rocks disintegrate, certain radio-active elements, such as uranium, which may be regarded as the ancestor of radium, are carried into the ocean, and either deposited mechanically, or subsequently abstracted from solution by living organisms, whose remains eventually reach the floor of the ocean.

Recent researches by Strutt, and Joly, prove that sedimentary and volcanic rocks forming huge areas, and of great thickness, are radio-active throughout, which fact is of much importance to geologists, as it may help to explain points hitherto obscure, though, as the investigations are little more than in their infancy, rushing into hasty conclusions should be avoided.

In addition to radium and uranium, thorium is another radio-active element, and cells of this readily illustrate what is termed, "the rise and decay of radio-activity," For example, if thorium

nitrate be dissolved in water, and ammonia added, a precipitate of thorium hydrate is formed, which can be collected on a filter paper. If this is washed with water, it will be found to be devoid of all trace of radio-activity for the time being, that of the original salt being found in the filtered solution. If, however, the precipitate be retained, it gradually increases in radio-activity until eventually it equals the original amount. Trustworthy evidence indicates that all radio-active substances are in a state of atomic-flux, and from the fact that uranium is always associated with radium, it would appear certain that the latter is a product arising from the disintegration of the former. The evolution of heat by these substances makes their study of great interest to geologists. If, according to Strutt, the crust of the earth contains radio-active substances in an average quantity, to a depth of about 30 miles, this would suffice to account for a large proportion of the terrestrial heat which escapes from the surface of the globe. Further, such amount of heat throughout the crust would be sufficient to account for earth movements. The fact that the emanation of radium causes colouration in minerals, glass, and other substances brought into contact with it is also of interest to the geologist.

REFERENCES :—

Those desirous of further information upon this important subject are recommended to read a book by Professor Joly, recently published, on "Radium and Geology," which contains numerous references.

"RECENT DEPOSITS IN AIREDALE."

Abstract of Paper read by E. HAWKESWORTH, *January* 15*th*, 1909.

Through the courtesy of Messrs. T. Pridgin Teale and Jas. E. Bedford, I have had placed in my hands, for review, a paper written by the late Mr. Thomas Pridgin Teale, F.R.S., F.G.S. (father of the former gentleman), "On the Aire Valley Deposit and its Organic Remains."

This paper was read before the Leeds Philosophical and Literary Society, on November 18th, 1853, the Leeds Mechanics' Institute, on March 8th, 1854, and the Yorkshire Naturalists' Club, at York, in June, 1854.

The "Organic Remains" are described by Mr. H. Denny, A.L.S., etc., in the Proceedings of the West Riding Geological and Polytechnic Society (now the Yorkshire Geological Society), vol. 3, p. 321, and in the same volume, p. 482, is a paper by Mr. Teale, Senr., "On some Works of Man Associated with the Remains of Extinct Mammals, in the Aire Valley Deposit."

So that, at present, nothing need be said here as to the organic remains, but it seems desirable that the sections of alluvial deposits

in the neighbourhood of Leeds, described in the paper, should be placed on permanent record, more especially so, as most of them are either removed or obscured by the complex requirements of a vast population.

In his introduction, the author expresses a wish that his paper should be looked upon only as a contribution to a much more extensive subject—the valley deposits of the tributaries of the Humber, and it is worthy of note that, apart from fragmentary observations, almost half a century elapsed before any further contribution of note was made to this important and interesting subject.

The paper is divided into four parts :—

1. The extent, distribution, and mineral characters of the Aire Valley Deposit."
2. " Its mode of formation."
3. " Its geological age."
4. " Its organic remains."

1. " The extent, distribution, and mineral characters of the Aire Valley Deposit."

I will quote fully from this part of the paper, as it contains the facts most worthy of record. (All the quotations are in inverted commas).

" The river Aire, arising in the elevated Mountain Limestone range of Craven, traverses, in an easterly direction, by a circuitous route, the Millstone Grit and sand-stone districts of Keighley, Bingley, Shipley, and Bramley, until it reaches Kirkstall Forge, three miles west of Leeds."

" Below Kirkstall Forge the lower valley of the Aire may be said to commence. At this place it suddenly expands, and presents a nearly level surface, about a quarter of a mile broad, through which the river runs. Below Armley the valley again expands, stretching out to a breadth of two or three miles, forming a plain on which are situated a large portion of the town of Leeds, and the townships of Holbeck and Hunslet. Below Leeds, this flat valley land, varying from one to three miles in breadth, extends downwards for about eight miles, until it becomes continuous with a similar flat valley land which extends several miles up the course of the Calder."

" This flat valley deposit rests in the neighbourhood of Leeds on the coal formation. The materials of which it is composed are clay, sand, and gravel, apparently distributed by one violent act of watery disturbance and deposition."

" The average thickness of the deposit in this district is from 10 to 20 feet, in some of the central places of the valley it is 30 or 35

feet, whilst, towards the borders of the valley it becomes thinner, and at a moderate elevation shelves off until it is entirely lost."

"The general form of the deposit may be learned by inspection of this transverse section from Wortley Lodge to St. Peter's Hill. This is the line of the brick-fields where the remains of the Hippopotamus were found."

"Commencing at the south bank of the river near Wellington Bridge, the deposit is 30ft. thick, and its surface 95ft. above the mean sea-level."

"At Mr. Longley's brick-field the deposit above the Coal Measures is 12ft. thick, and the surface level 110ft."

"At Mr. Hobson's field the deposit is 7ft. thick, and the surface level 125ft."

"At Oldfield Lane Bar the deposit is 2½ft. thick, and the level 145ft."

"At the middle of the lawn at Wortley Lodge the level is 150ft., and the deposit is then nearly lost."

"At the north bank of the river, near Wellington Bridge, the deposit is 35ft. thick, it rises more rapidly than on the south side, becoming thinner, and is lost at the Wesleyan Chapel, St. Peters Hill, at an altitude of 150ft."

"The height at which the deposit wears out on the north and south boundaries of the valley, namely at 150ft. above the sea-level, is important to be borne in mind, as it is the key to the future part of this paper.'

"The materials of which this deposit consists are clay, sand, and gravel, with the bones of various quadrupeds, and the roots, trunks, and branches of drifted trees, and their fruits."

"The gravel consists of stones rounded by the action of water, and derived chiefly from the grit-stones and other sandstones of the upper part of the district of the Aire, with occasional pieces of chert from the Mountain Limestone district of Craven. In the midst of the gravel are found occasionally large boulders of grit-stone and other sandstone from 2 to 3ft. in diameter."*

"The sand and clay vary very much in character, the former from a coarse rubble to fine river sand, the latter from a soft yellow clay to a dark blue tenacious earth, or to non-adhesive black mud."

"These materials of the valley deposit, namely the clay, sand, and gravel, do not occur in a regular order of super-position. They often pass by a rapid transition from one to another, a bed of clay passing into sand or gravel within a very short distance, thus giving evidence of the local distribution of the materials

* Similar boulders are found in the higher deposits. In both cases they *may* have been dropped by icebergs (E.H.)

having been much influenced by currents and eddies. Of this fact abundant evidence has been afforded during the late excavations for the sewerage. For example, within the range of one street, namely Greenwood Street, Hunslet, the following varieties in the deposition were observed at four different points,—

1. Clay. 2. Gravel, clay, gravel. 3. Clay, sand, gravel. 4. Gravel, clay."

"In Greenwood Street, at one point there is clay several feet in thickness resting on the Coal Measures, without sand or gravel, whilst in the neighbouring Wesley Street, there is many feet in thickness without sand or clay."

"In the small extent of the excavations at the brick-field where the Hippopotamus remains were found, great varieties in the characters of the deposit were seen. In one section there appeared clay 5 or 6ft.; grey sand 2ft., beneath which is some white sand containing rolled stones. In another direction, in the same excavation, a bed of dark red gravel occurs, whilst in the particular spot where the bones of Hippopotamus were found there was neither sand nor gravel, but clays of various qualities."

"I have dealt upon these details because from them an important inference may be drawn, namely, that this deposit of clay, sand, and gravel was not the result of a long process of deposition, in which the different materials would have been respectively spread in a regular series over wide areas, but that it must have been produced by one violent commotion, one enormous land-flood. This inference is further strengthened by the negative fact of the absence of beds of shells, or of peat, in the real valley deposit wherever it has been carefully examined."

To sum up these observations—certain very variable deposits of clay, sand, and gravel occur in several places in the vicinity of Leeds, up to a height of 150ft. above the sea-level.

This contribution does not appear to have had its desired effect in inducing others to take up the elucidation of these valley deposits, and subsequent references to them in geological literature are extremely meagre. The Geological Survey does no more than mention them as river terraces. In 1890, Mr. B. Holgate, F.G.S., read a paper before this Association on "A Long-buried Oak,"* in which he described a fine specimen of an oak tree found in making an excavation in the yard of Messrs. Tetley's Brewery.

†Messrs. Jowett and Muff allude to certain recent deposits in Airedale in their paper on the "Glaciation of Bradford, etc.,"‡ and the present writer has described sections of somewhat similar

* L. G. A. Transactions, pt. vi. p. 47.
† Proc. Yorks. Geol. and Poly. Sty., vol. xv., p. 245.
‡ Trans. Leeds Geol. Assoc., pt. xiii., p. 34.

deposits, but at a higher level, in the Aire Valley, at Rothwell and Oulton, besides referring to smaller occurrences of drift east of Leeds, between the Aire and Wharfe.

2. Mode of Formation.

It would be manifestly unfair to approach this part of the paper in a spirit of criticism, for, it must be remembered that half a century ago very little was known about recent deposits. The interest lays rather in seeing the growth of knowledge by contrasting the ideas of the middle of the nineteenth century, with those of to-day, and one is compelled to admire the true scientific method in noting the facts.

As to the mode of formation of the described deposits, Mr. Teale "offers the following conjecture." "That the waters of all the tributaries of the Humber were formerly pent up by a barrier of rocks, formed by the Lias, Oolite, and Chalk strata which now constitute the line of hills ranging from the Yorkshire Wolds to the north bank of the Humber at Brough, and again appear at the south bank, and extend southwards through Lincolnshire and the Midland counties to the west of Dorset; that this barrier existing to the altitude of 150ft. or thereabouts dammed up the waters of the tributaries of the Humber, forming a vast inland lake, and that by an enormous land-flood the rocky barrier was broken down—the lake drained, and the valleys of the tributaries were strewn over with the wreck of the strata which they had traversed, and with the materials of the Northern Drift which it had displaced."

"Supposing this barrier to have existed to the height of 150ft. or so, it would have the effect of damming up the waters of the Aire to the height at which we find the valley deposit wearing out at Wortley and St. Peter's Hill. Its influence would be felt in all the tributaries until they reached an altitude beyond 150ft. The general effect of this obstruction across the Humber would be to produce a vast inland lake, extending from beyond Northallerton in the north, to Derby in the south, a distance of 120 miles, and from Kirkstall Forge in the west, to Brough on the Humber in the east, a distance of 45 miles. It would obstruct the waters of the Derwent, thus forming a smaller lake of the Vale of Pickering, communicating with the large lake of York and Trent by a narrow gorge at Malton."

The author goes on to argue that the wearing down of the barrier may have been due to a long slowly acting cause, or to a violent and transitory one, instancing Niagara in favour of the former. Such a continuous action of running water may have weakened the barrier, but he conceives "the final disruption must have been due to a more sudden and violent agent," namely, an immense *land flood*. The Holmfirth flood of 1852 is instanced,

and, if the effects of a heavy rainfall upon an artificial barrier across a single tributary rivulet of the Humber were so destructive, we may easily imagine how a rainstorm, much greater and more prolonged, acting upon the whole Humber drainage system, " may have poured down such a mighty mass of waters as may have broken through a barrier which heretofore was sufficient to keep within its bounds the tranquil though extensive lake.

Various facts are brought forward in proof of the existence of this lake to a level of 150 feet, and the local ones are here quoted.

" In pursuing upwards the little tributaries of the Aire, near Leeds, each is found to have its little slip of valley-deposit, until it has reached fairly beyond the level of 150ft. Adel Beck reaches this height at the pond near Battey Wood. To this point, through the field beyond, the flat extends, and there ceases. Gledhow Beck reaches the level of 150ft. at the ford in Harehills Lane. The flat surface is continued through the field above, but ceases at Gledhow Wood. Halton Beck reaches 150ft. at Fearneville, near Roundhay. To this place the flat valley aspect is observed, but is lost as the stream is traced upwards to the foot of the waterfall from Roundhay Park. The Hol Beck reaches 150ft. at Millshay pond, between Beeston and Churwell. Up to this there is a well marked valley district which ceases towards Morley."

" In all the tributary vallies of the Aire near Leeds, within the level of 150ft., is a small but well marked flat valley surface. Various places in and near Leeds, at this level, and within it, are mentioned, but need not be quoted here, as they can be traced easily on the map."

" In the sections exposed above this level, the Coal Measures are uncovered by the valley deposits. In Rockingham Street, sandstone was at the surface at a level of 175ft., and in Coburg Street at 195ft. In Woodhouse Lane, below Carlton Hill, it was exposed at 215ft., Burley at 190ft., and in the new railway cutting at Armley, at 200ft. The lane from Roundhay Road to Gledhow Wood exhibits a section of Coal Measure sandstones quite uncovered by the valley formation, which is important, as it commences at the rising ground immediately above where the valley ends at 150ft."

3. Geological Age of the Aire Valley Deposit.

According to the author, a great change took place at the close of the Tertiary period. These islands " became depressed many hundreds of feet, and the surface " submerged beneath the ocean," " with the exception of the higher mountain ranges which would then stand out above the waters as clusters of islands. The greater part of the northern hemisphere suffered the same fate."

"It is shown by indisputable evidence that Britain was thus depressed to the extent of 1,600 feet or more. The islands formed by its mountain ranges were capped by snow and their ravines filled with glaciers, which, descending to the sea, and becoming detached, floated as icebergs fraught with huge blocks of stone." As the icebergs drifted southwards, and melted, their rocky freight was dropped in the form of our well known erratic blocks.

This condition is assumed to have existed for only a short time. The land was raised to almost its former elevation. Besides the erratic blocks, on its surface "were enormous accumulations of mud, sand, gravel, and boulders, forming in some places beds several hundred feet in thickness," these being known as "the Northern Drift, or Boulder Clay formation."

"During this commotion there was a great destruction of animal life. Numbers took refuge in their caves, and were there entombed in mud and gravel, as at Kirkdale, Wirksworth, and numerous other places. A few escaped to the mountains and survived the storm. Many species became totally extinct." The deposit described, in the valley of the Aire and the other tributaries of the Humber is newer than the Northern Drift, and the opinion of Professor Phillips is quoted that "it is of sufficient importance to be regarded as a valley formation, and that it is decidedly of Post-glacial age."

To comment in detail upon the points raised in this interesting old paper, would entail a discussion of many geological events, such as would here be out of place. The postulation of a Lake Humber and Pickering is of distinct interest, though the assumed cause must be ruled out of court. The escarpment of secondary rocks in the east of England, which probably once extended much farther westward than now, and was also higher, must have undergone very extensive denudation, and been cut through by rivers draining from the west, long anterior to the Glacial Period. If this escarpment ever did form a barrier pounding back the westward drainage, it would do so at a greater height than 150ft., as even now, much of it is well above that level. Beyond this, taking only into account land barriers, there appears to be no reason why one at that height to the eastward, should not cause the drainage to flow out northwards over the present low watershed between the Vale of York, and Tees, or even to the southwards.

But present day knowledge enables us to speak with certainty as to the cause and approximate age of the deposits described by Mr. Teale, so many years ago. We know, the evidences need not be repeated here, that, in the Glacial Period, the North Sea was filled with ice, and this, and its consequent moraine, obstructed the natural drainage of the greater part of Yorkshire, even permanently diverting some of it.

The Tees valley was filled by a great glacier, as was the Vale of York. During some part of the period, the north-western vallies had their local glaciers, those of the Nidd, Wharfe, and Aire at one stage probably extending to the Vale of York.

In this connection the high-level drift deposits of the district must be considered. These are mainly of the same character as those described, but of greater thickness, and at elevations from 50 to 150ft. higher. These can scarcely have been formed in Lake Humber, which does not appear to have been more than 200ft. deep. Their occurrence on the ridge dividing the Aire and Rothwell vallies, and the latter from Calder dale, with traces of drift, with similar contents, on the water-shed between Aire and Wharfe, seems to point to a confluence of these rivers at their eastern end, leading to the question as to what was the cause of this. At present, I can only hazard my opinion that these are due to the chapter of events sketched by Mr. W. Lower Carter in his paper on the "Glaciation of the Don and Dearne Valleys" (Proc. Yorks. Geol. Sty., vol. xv., pt. 3). To quote these briefly—in the early stages of the Glacial Period, glaciers from the principal Pennine valleys became confluent in the plains, filling up the vales of Mowbray and York. The Stainmoor glacier thrust aside and over-rode the Vale of York ice, preventing further eastward flow of the Pennine glaciers, and crowding them back against the lower slopes of the Pennines. Then the Pennine ice tended to retreat, but the Stainmoor glacier increased, filling the central valley, and holding up the drainage of the receding ice in the western vallies, thus forming a series of lakes. The high level deposits of the lower parts of the Aire and adjacent vallies seem to have been formed in such a lake, and at least some of them may be moraines, re-arranged, to some extent, by water action, as all terminal moraines must be, to a greater or less extent.

From the detached position of many of these older morainic-lacustrine deposits, it can be inferred that they must have undergone extensive denudation, as the waters subsided, and the drainage tended to a more normal course.

The stones contained in both the higher and lower deposits seem to be of the same character, with the exception that there is no record of any pre-carboniferous rocks being found in the lower ones.

This similarity in character of the deposits themselves, and their contents, leads one to suspect some relationship between the two, but whether this is really so, and if so, what it is, I am at present unable to decide. The higher ones are certainly not a river-terrace, the lower ones may be, or they may belong to the Lake Humber stage, when the drainage of that basin was held up by the North Sea Glacier.

However, putting the ideas of half a century ago in bold contrast with those of to-day, based as they are on wider knowledge of the various phenomena involved, we may safely say that there is little or no evidence that the escarpment of secondary rocks was continuous in post-glacial times ; nor of any pre-glacial subsidence and subsequent re-elevation. The old theory of the Northern Drift period, with its short duration, has had to give way to that of a long Glacial Period, in which the main sequence of events is now well known, though the problem of its cause still remains unsolved.

SOME BOULDER-LIKE MASSES (IN FIRECLAY) AT KILNHURST,

Read by E. HAWKESWORTH, *January 15th*, 1909.

In September last, I received a communication from the late Mr. Enoch Jagger, of Kilnhurst, to the effect that a large boulder had been found in course of working a bed of fire-clay at the brick-works of Messrs. J. & J. Charlesworth, Ltd., at that place. Being aware that small boulders have been found at times in the Coal Measure rocks, and having specially in mind the paper in vol. 3 of our Transactions, recording some found at Wortley, near Leeds, some years ago, I considered the matter worthy of investigation, so at once requested Mr. Jagger to obtain a photograph of the one he mentioned, and to furnish further particulars. He very kindly did so.

The section exposed is in the Middle Coal Measures, about the horizon of the Middle and Lower Chevet Rock, the bed of fire-clay being about 260 yards above the Barnsley Coal. The floor of the excavation is a hard sandstone, probably the Oaks Rock, which, at the adjacent colliery, was met with at a depth of 66½ feet, and had a thickness of 98 feet. The so-called boulders rest on this floor, and are embedded in a bed of fire-clay 5 to 6 feet in thickness, upon which is a seam of coal 4 or 5 inches thick, which is succeeded by a bed of yellow clay. The beds dip to the N.E. Several large boulder-like masses have been found here during the last few years, near the outcrop, but the one shown in the accompanying plate is the largest. *In situ*, they are described by Mr. Jagger as being comparatively soft, but after exposure for some time become very hard, brown to dark grey in colour, and " flint-like." It has been possible to break them up by making a fire on and around them.

A fortnight later another mass was found within a few feet of the above, but, owing to the working of the clay being stopped, was not sufficiently bared to allow of its being photographed or measured.

The first mentioned mass is about 3 feet thick, shaped somewhat like a kidney, about 9ft. long, and 3ft. wide in its narrowest part.

I paid a visit to the section, and found that the specimen originally sent me by Mr. Jagger was only a sort of coating round the mass. It has been examined by Mr. A. Gilligan, B.Sc., who very kindly informs me that it consists of :—

Calcium carbonate.
A little Magnesium carbonate.
Iron oxide.

and about 40% of matter insoluble in H.Cl., mostly silica.

A look at the two masses soon convinced me that they could not be boulders. Their size and position precludes the idea, and their composition, inside the coating referred to seems, to the eye, very similar material to the surrounding fire-clay. I am again indebted to Mr. Gilligan for an examination of this, which he finds to be largely composed of calcite, with large secondary crystals of the same mineral, and patches of chlorite produced by decomposition of some ferro—magnesian mineral. Scattered throughout the mass are small pieces of quartz.

The masses, therefore, appear to be of concretionary origin, or are hard parts of the bed in which they lay. Their greater hardness may be due to some infiltration from higher beds, the coating suggests this, and the presence in it of Mag. carb. may indicate infiltration from once overlying Magnesian limestone, the outcrop of which is only a few miles to the eastward.

On the other hand, these harder masses may represent the original condition of the bed, the surrounding softer fire-clay being in that condition owing to the influences of atmospheric agencies at the outcrop.

I must express my great indebtedness to Mr. Jagger, for furnishing the particulars of this section, and the photograph.

"THE APPLICATION OF GEOLOGY TO PUBLIC WORKS CONSTRUCTION."

Abstract of Paper read by H. LAPWORTH, D.Sc., F.G.S., A.M.I.C.E., *March 19th*, 1909.

A large number of instances were mentioned and illustrated by blackboard sketches of public works of various kinds—reservoirs, embankments, aqueducts, wells, railway cuttings, and tunnels, in which, owing to neglect of the preliminary study or ascertainment of the geological conditions, the estimates of cost had to be exceeded by tens of thousands, or, in some cases, hundreds of thousands, of pounds, or such large sums had to be spent subsequently in rectifying previous errors which might have been avoided by an early appreciation of the proper structure of the rocks beneath the surface.

SECTION AT KILNHURST, looking Westerly.

This shows the vital importance of a knowledge of geology to the civil engineer, or of having a minute investigation of the district to be worked in made by an expert geologist. Even a comparatively large sum of money spent in this way may result in the saving of huge sums eventually. The truly economical carrying out of public works must depend upon a knowledge of what to expect below ground, and more particularly what kinds of geological structure to avoid. Unfortunately the majority of engineers have no idea of the practical side of the science ; they treat geology with indifference, in some cases, with contempt. Men who have by skill and good judgment risen to the top rank of the profession have been ignorant of the principles of stratification, and have flouted the idea of foretelling underground structure.

This lamentable ignorance is largely due to the poor teaching of science in the schools, and many of the Universities. There has been some improvement during the last decade or two, but it must be slow, so long as the classical traditions of the older Universities hold sway. Science teaching in most schools consists of a few hours' chemistry and physics weekly, with occasionally botany and physiography, but rarely geology. A knowledge of Cicero and Greek verse is esteemed of more importance than an acquaintance with the meaning and origin of the ground the student walks upon. The cost of public works of even moderate size is very high. Fifty or a hundred thousand pounds is quite an every-day figure, and the sum, in many cases, runs into millions. Unfavourable geological formation may easily add a quarter of a million to the cost of a large scheme. It must be obvious that if only a fraction of such extra expenditure can be avoided by geological knowledge, the most thorough examination should be made before locating the site of works of such magnitude, and local authorities should insist upon this. Further, it is essential that the civil engineer should be properly trained at school and college, so that he may be competent to deal with the multifold geological problems that arise during the construction of such works. As the knowledge of geology spreads, and as the errors arising from its neglect become more apparent in the community, it will be recognised as fully as essential a practical factor in public works construction as bacteriology is in the practice of surgery, or astronomy in practical navigation.

This paper is published in full in the Proceedings of the Institute of Civil Engineers, Vol. clxxiii., pt. 3.

"PHYSICAL AND BIOLOGICAL CHANGES AT THE CLOSE OF THE CRETACEOUS PERIOD.

Abstract of paper read by PROFESSOR P. F. KENDALL, M.Sc., F.G.S., *November 20th*, 1908.

At the close of the Mesozoic period, there were physical changes of considerable extent, resulting in discordance of the rocks over large areas. In a small area, as for instance the London Basin, the unconformity between the Cretaceous and Tertiary rocks is difficult to see, but taking the world over, it is very marked. But the biological change between the two periods is enormous, and the break is markedly abrupt, especially in the fauna. Amongst the vertebrates, the reptiles, so numerous as to cause the Secondary rocks to be known as the "Age of Reptiles," were, in Tertiary times, succeeded by great numbers and variety of mammals, whilst, amongst the invertebrates, the cephalopoda, so characteristic of the Jurassic and Cretaceous rocks, almost died out, their places being taken by gastropoda and lamellibranchs, in great profusion. The cycadaceous plants, the predominant vegetation of Secondary times, suddenly disappeared, and, in their stead, flowering plants (Angiosperms), similar in family and genus to those still flourishing, come in at the commencement of the Tertiary period.

Such an abrupt termination of life forms predominant over long ages, and such a sudden incoming of distinctly new forms, not merely of species, or even genera, but of family, calls for some explanation. Where did the numerous new and highly organised types originate? One cannot imagine a sudden evolution of such magnitude, and migration is the only feasible explanation. Some long antecedent period of evolution seems necessary to account for their development, evolution in a large area, with strong competition, which is proved by the survival of so many forms to the present time. This evolution may have been worked out in regions which have now disappeared, or in regions geologically unexplored, but as the only such parts of the earth are the Antarctic continent, and Greenland, one is almost forced to the conclusion that these new and lusty types of life were evolved upon, and migrated from, some Mid-Atlantic continent, a geological Atlantis, now disappeared. Both lithological and biological evidence can be adduced in favour of this hypothesis. In all the divisions of the Palæozoic rocks, Cambrian to Trias, there is a coarsening of sediments towards the Atlantic shores on both sides, proving the proximity of a great land mass between the two hemispheres. The Mesozoic rocks furnish but little evidence of this..

The biological evidence in favour of such a land mass is equally interesting. The fishes, so characteristic of Palæozoic times, are remarkably similar on both sides of the Atlantic, probably as high a

proportion as 30 per cent. being common to the rocks of both continents. In the Mesozoic period the fauna and flora of the two areas differed widely. Reptiles were present in enormous numbers in both hemispheres, about 330 genera being known, of which only ten are common to both hemispheres. The ichthyosaurs and plesiosaurs, so abundant in the European rocks, are absent in America. As these numerous reptiles were represented by species inhabiting both land and sea, as well as flying ones, they afford strong evidence against any land connection between the two continents in Jurassic times.

With regard to the hypothetical continent, and its disappearance, the lecturer proceeded to show that a local rise of sea-floor would cause a rise in the level of the sea all over the globe, and a consequent transgression of the land by water. There is clear evidence that such a transgression was in progress during the deposition of the Gault and Upper Greensand, not only in Europe, but in America. The final break-up of the continent would take place during the close of the Cretaceous period. These changes of level would no doubt result in a variation of climate, which would have considerable influence upon the vegetation, and, following that, upon animal life. This break-up of the continent resulted in the incursion of new forms of life from the previously unconnected ocean. The angiospermous plants matured and multiplied far more rapidly than the cycadaceous ones which they soon exterminated. These cycads furnished the food supply of the reptiles, and, when it failed, they died out, the newly prevailing vegetation being followed up by a rich mammalian fauna. Similarly the marine reptiles were exterminated owing to their food supply, the cephalopoda, having been ousted by the gastropoda. But the conclusive evidence as to the position and certainty of the breeding ground for Tertiary plants and animals is yet to be found, and there is still much to be learnt about the breaking up of this old continental area, and its influence upon the food supply, which is the dominating factor in the change of flora and fauna.

"THE GLACIAL HISTORY OF HOLDERNESS."

Abstract of Paper read by MR. THOS. SHEPPARD, F.G.S., *April 30th*, 1909.

The history of the study of the subject, and its literature, were first reviewed. This "desert of drift," as it was once termed by a well-known cleric, now deceased, was shown to abound in interest to the geologist, and the stages of its glacial history are clearly exhibited in a variety of phenomena. The Boulder Clay of the district is divided into upper, middle, and lower. The latter is of limited occurrence, but is found at Dimlington and Bridlington.

It is of a leaden colour, very stiff, with a great deal of chalk included, and differs from the other divisions in that it contains quantities of marine shells, many of Arctic type, which have been scooped up from the bed of the North Sea by the glacier which crossed it from Scandinavia. The middle, or purple clay, is the most important division, covering, as it does, the greater part of South-East Yorkshire. It contains large numbers of boulders from widely different localities, various igneous rocks from the Lake District, Scotland, and Scandinavia, the Cleveland Dyke, and Whin Sill from Teesdale, Carboniferous limestones and sandstones in great profusion, and representatives of all the Secondary rocks present in the North of England. The upper, or Hessle clay, on the contrary, contains few boulders, they are of small size, and a large proportion of them are porphyrites and similar rocks from the Cheviot area.

Glacial striæ are rare in South-East Yorkshire, but such as have been observed agree with the numerous instances in the other parts of the county in showing the direction of the ice-flow, which is also further proved by the crumpling of the rocks immediately beneath the boulder clays, caused by the pressure of the ice-movement. The gravel deposits connected with the boulder-clay are of great interest. They are well shown at Burstwick and Kelsey Hill, where they contain a number of mammalian remains. During the past few weeks, the leg bone of a mammoth, the antlers of red deer, and bones of bison have been found at the latter locality. Marine shells, similar to those in the lower clay, are present, along with large numbers of Cyrena, a fresh water form. In the gravel at Bielbecks, bones of the lion, bison, elephant, rhinoceros, and other mammals have been found.

The whole of Holderness is made up of glacial débris. Before the glacial period the sea cliffs followed a line from Sewerby, by Driffield, to Hessle. Borings at various localities prove this, and the pre-glacial sea beach has been exposed at Sewerby. The Humber flowed directly eastward to the sea, its southerly diversion being caused by a mass of morainic material.

Piecing all the evidence together, it is seen that, following a gradual advance of Arctic conditions, a glacier came across the North Sea, from Scandinavia, depositing the lower clay. Then another came along from the North-West of England, down Teesdale and the coast, which laid down the middle clay, and was followed by another from the Cheviots, the débris of which is found in the upper clay. A moraine was left across the Humber, and subsequently cut through. It is seen at North and South Ferriby, on both sides of the river. This would dam up the great Humber drainage system, forming Lake Humber. Several meres were formed in the hollows of the moraines constituting Holderness. Owing to the erosion of the sea these have all disappeared

except that at Hornsea, but the beds of the lost ones are sometimes seen in the cliffs, and yield remains of animals and plants which flourished in or near them, which clearly show a gradual amelioration of climatic conditions.

REFERENCES :—

The literature of this subject is extensive, and many papers upon it are published in the Proceedings of the Yorkshire Geological Society, the Transactions of the Hull Geological Society, the Reports of the British Association, and the "Naturalist." Mr. Sheppard's "Geological Rambles in East Yorkshire" may also be consulted.

REFERENCES TO THE SUBJECTS OF OTHER PAPERS READ.

"MARINE BANDS IN THE MILLSTONE GRIT OF WHARFEDALE," read by G. V. WILSON, B.Sc., Feb. 26th, 1909. *This paper is published in Proc. Yorks. Geol. Society, vol. xvii., pt.* 1.

"SOME EFFECTS OF THE CLOUD-BURST OF JUNE, 1908, IN WHARFEDALE," read by A. GILLIGAN, B.Sc., May 21st, 1909. *This paper is published, with illustrations, in Proc. Yorks. Geol. Society, vol. xvi., pt.* 3.

Thirty-Sixth Session, 1909-10.

Officers:

President: C. T. WHITMELL, M.A., B.Sc.

Vice-President: F. W. BRANSON, F.I.C.

Hon. Secretary and Treasurer: E. HAWKESWORTH, Sunnyside, Crossgates, Leeds.

Members of the Council:

GODFREY BINGLEY.
ARTHUR BURNET.
A. CHARLESWORTH, M.Sc.
C. A. CHEETHAM.
S. W. CUTTRISS.
A. R. DWERRYHOUSE, D.Sc., F.G.S.
J. H. EVERETT, B.Sc.
D. FORSYTH, M.A., D.Sc.
A. GILLIGAN, B.Sc.
Prof. P. F. KENDALL, M.Sc., F.G.S.
STANLEY NETTLETON.
W. PARSONS, F.R.G.S.
HENRY SMITH, F.I.P.S.
Prof. G. R. THOMPSON, B.Sc., F.G.S.

ANNUAL REPORT.

The session just ending has been quite as successful as previous ones. The membership is well maintained, the meetings have been well attended, the lectures and papers have been of great and varied interest, in many cases giving rise to useful discussions. The financial position is quite satisfactory.

MEETINGS.—Eight evening meetings have been held as follows:

1910.

Oct. 15—Opening meeting of the session.

PRESIDENT'S ADDRESS: "The Origin of Lakes" (*Illustrated by lantern slides and diagrams*).

EXHIBITS: microscopes showing sections of North of England igneous rocks. The latest geological maps. The STAFF of the GEOLOGICAL DEPARTMENT of the UNIVERSITY.

A geological map of Yorkshire, in relief. Reproductions of plates of fossils from Phillips' Geology of Yorkshire, reduced to pocket size, along with the original plates.

Specimens of Triassic rocks passed through in a deep boring at Bickerstaffe.

Specimens of rocks from the Holyhead district. W. THORNBER.

Coniston Limestone fossils from Ingleton, Clapham, Helm Gill, and Spen Gill. Specimens of igneous dyke, and rocks in contact with it, from Helm Gill, Dent Dale. E. HAWKESWORTH.

Nov. 19—" Cannel and its Affinities." STANLEY NETTLETON. (*Illustrated by a large collection of rock specimens, and fossils*).
Exhibition of lantern slides showing geological features in the Kirkby Lonsdale district; on the coast from Cloughton to Hayburn Wyke; also a series of about 40 slides showing the variations in the sections exposed in the working of the Meanwood Ganister quarry, from 1891 to 1909. GODFREY BINGLEY.

Dec. 17—" Salts in Solution in River Water, and what becomes of them." A. GILLIGAN, B.Sc.
Exhibition of maps, plans, and drawings of sections passed through in making 28 trial holes in connection with the new sewerage scheme, from Morris Lane, Kirkstall, across the city, to its eastern boundary, near Templenewsam, also boxes containing specimens, to scale, of the strata passed through. GEO. A. HART.

1910.
Jan. 21—" The Origin of the Trias." PROF. P. F. KENDALL, M.Sc., F.G.S. (*Illustrated by lantern slides, diagrams, and specimens*).
Exhibition of fossil plants from the Lower Keuper, near Bromsgrove, as described by L. J. WILLS, B.A., F.G.S., Proc. Geol. Assoc., vol. xxi., pt. 5. Lent by the Sedgwick Museum, Cambridge.

Feb. 21—" With the British Association in Canada." (*Illustrated by lantern slides*). A. R. DWERRYHOUSE, D.Sc., F.G.S.
Presentation of Testimonial to Dr. Dwerryhouse.

Mar. 18—" Reef Knolls." ERNEST PARSONS, B.Sc. (*Illustrated by lantern slides, and specimens*).
" Some deep Borings in the South East of England." A. NOBLE, B.A.

April 15—" Some Points of Contact between Geology and Astronomy." ARTHUR BURNET.

May 6—ANNUAL BUSINESS MEETING. Adoption of Report and Balance Sheet. Election of Officers.
" Fossil Plants." (*Illustrated by specimens and microscope slides*). WM. HEMINGWAY.

The average attendance at these meetings was about 35.

SPECIAL MEETINGS.—On November 2nd, a large number of our members attended a lecture by Professor W. H. Bragg, M.A., F.R.S., before the Leeds Philosophical and Literary Society, on " Radio-activity, the new Science," by invitation of the president of that Society (Rev. J. R. Wynne-Edwards, M.A.). On January 11th, Dr. Tempest Anderson, B.A., F.G.S., lectured before the Leeds Photographic Society on " Mexico," and many of our members accepted the invitation of the president and members of that society to attend.

These invitations to attend the meetings of kindred societies are highly appreciated by the Association.

EXCURSIONS.—The following excursions have been held:

1909.
May 8—Market Weighton (Y.N.U.) Jurassic and Cretaceous.
Leader: J. W. STATHER, F.G.S.
24—Woodlesford. Coal Measures and Recent.
Leader: ISAAC HODGES, F.G.S.
29—Bowland (Y.N.U.) Lower Carboniferous.

June 11—Meanwood. Coal Measures.

July 10—Runswick (Y.N.U.) Jurassic and Glacial.

17—Ingleton. Pre-carboniferous, and Lower Carboniferous.
Leader: E. HAWKESWORTH.

31—Sedbergh (Y.N.U.) Silurian and Lower Carboniferous.
Leaders: W. ROBINSON and E. HAWKESWORTH.

Aug. 28—Cawthorne. Coal Measures.
Leader: REV. C. T. PRATT, M.A.

The excursions arranged by the Association were badly attended, and it is to be regretted that so few of our members avail themselves of the excursions of the Yorkshire Naturalists' Union.

LIBRARY.—The publications of various societies and institutions have been received, and, by the kindness of Mr. Arnold Lupton, the Q.J.G.S. is received as published. The library has been made use of rather more than usual by members engaged in research work.

TRANSACTIONS.—It is hoped to issue part 15 before the end of this year, bringing the Transactions up to the end of the present session.

The sale of back parts has realised £2.

MEMBERSHIP.—During the session 17 ordinary members, and 1 associate have joined the Association, and two associates have become members. On the other hand, 7 ordinary members, 1 country member, and 7 associates have resigned, or died, which leaves the roll as follows:—8 Honorary Life Members; 90 Ordinary Members; 9 Country Members; 13 Associates, a total of 120, showing a net increase of 2 over the previous session.

COUNCIL.—There have been four meetings of the Council, with an average attendance of 10.

On Dr. Dwerryhouse leaving Leeds to take up an appointment as Lecturer in Geology in the University of Belfast, it was felt that he should be given some token of the appreciation the members had for the many services he had rendered to the Association. A fund was opened, as a result of which Dr. Dwerryhouse was presented with a surveying aneroid, suitably inscribed, on February 25th.

A large number of trial holes covering a line of some miles across the city, in connection with the new sewerage scheme, have been made by the corporation, and the drawings of the sections of these, along with boxes containing specimens of the rocks, in order, and to scale, were exhibited at one of our meetings. It was thought that these section boxes, after serving their original purpose, should be preserved for permanent reference, and it is

satisfactory to note that the Sewerage Committee of the Leeds City Council has promised that they shall in due course be handed over to the Association, for the University collection.

In conclusion, your Council desires to express the sincere thanks of the Association to the readers of papers, and those who have exhibited specimens, slides, etc., at the meetings; to the leaders of excursions; to the Leeds Photographic Society, and the President of the Leeds Philosophical and Literary Society, for invitations to attend lectures; to Mr. Arnold Lupton for his gift of the Q.J.G.S., and to other donors to the Library; to the authorities of the University for allowing the use of the rooms; and to the staff of the Geological Department of the University, whose services in many directions have added materially to the success of the meetings.

"THE ORIGIN OF LAKES."

Abstract of Presidential Address by MR. C. T. WHITMELL, M.A., B.Sc., *October 15th*, 1909.

There is hardly any point in physical geography which presents more difficulties than the origin of lakes. Rivers cannot make them, for water does not make a hollow below its level, and then flow uphill, and wherever a stream, carrying solid material, enters a lake, we find that the lake is being slowly filled up by the deposition of this material. (Many well known examples were given). As many lakes have thus become dry land, and others are disappearing, we may conclude that, geologically regarded, their origin is recent.

In dealing with the problem, the late Professor Ramsay pointed out the greater abundance of lakes in the more northerly parts of the earth, and their comparative rarity in tropical regions. They mostly occur in hollows among the older rocks, which have undergone enormous denudation, and of which the original surfaces have disappeared long ago, so that in most cases the present dips or folds of the strata have no relation to the basins of the lakes.

Lakes may be roughly divided into two classes, those formed by barriers of superficial accumulation, and those which lie in hollows below the general level.

CLASS I.

Among the former are lakes, usually temporary, due to a tributary stream having its waters ponded back by a deposit of material across its outlet by the stream of which it is a feeder; those due to landships, blocking up valleys, thus intercepting the drainage; those formed by the moraine of a glacier thrown across

a valley ; those in which the drainage of a tributary valley is held up by a glacier flowing down the main valley ; those formed in the hollows of irregular deposits of loose material, such as moraine mounds and hills of blown sand ; those formed in old volcanic craters and by the ponding back of a river by a lava stream crossing its valley ; and others.

Of the large temporary lakes, formed in England during the retreat of the great ice-sheet, I shall not attempt to speak. Professor Kendall has made this subject his own, and we may well be proud of his splendid work.

Class 2.

Lakes in rock basins form by far the more important class. A few of these may be due to subsidence, caused by the solution of underlying rock salt, gypsum, or limestone, but such lakes are rare.

Earth movements, such as the sinking of the upper, or the raising of the lower part of a valley, may give rise to lakes, often on a grand scale, and it is generally held that the five great fresh-water lakes, associated with the St. Lawrence River, are due in part, at any rate, to differential movements. But it would be absurd to attempt to explain by such movements the origin of the thousands of lakes of all sizes scattered broadcast over wide northern areas.

All the causes, hitherto given, will account for only a small number of lakes. There is one grand general cause, which appears to be the only one competent to account for the great majority of rock-basin lakes. That cause is Ice, which, in the form of glaciers, has scooped out the hollows. Professor Ramsay originated this theory in 1859, and it has ever since given rise to much discussion. It at once explains the abundance of lakes in the northerly latitudes, and their lying in rock-hollows. No other atmospheric agency can form these. The sea cannot make a hollow below its own average level ; rather, by re-arranging the sediments carried into it by rivers, it tends to fill up hollows. Rivers cannot make large basin-shaped hollows, surrounded by rocks ; all they can do is to cut out a ravine, gorge, or valley.

One strong point of evidence in favour of the glacial erosion theory of the origin of lakes, is that the longer axes of the lakes, in many cases, coincide with the general direction of the ice-flow over the country. Ramsay states that in the Alps all the large lakes lie in the direct channels of the old glaciers, and, where there are no traces of glaciers having flowed, there are no lakes. All the recognised proofs of the former existence of glaciers, smoothed and striated rock-surfaces, moraines, boulder-clay, erratic and perched blocks, are present in the districts where lakes abound.

A glacier creeping down a valley, must exert a great pressure upon the more level ground which it eventually reaches, especially when the slope of the valley is steep. The ice, into which are frozen numerous rocky fragments, will grind out a hollow, which will be lengthened and deepened as time goes on. The upper slope of the basin will usually be steeper than the lower. Down the former the ice slides with gravity in its favour, while it has to move up the latter against gravity, so that a greater quantity of rock is removed, and a steeper face produced, at entering than at leaving. As the ice goes sliding up out of the basin, its velocity and thickness alike diminish, so that a very gentle slope results towards the lake-foot. The narrowing of the valley at any part may strangle the ice into thicker masses, and cause a deeper dig into the rocky floor.

Lake Geneva.

As Professor Ramsay held that the basin of Lake Geneva was due to ice, I will give a brief summary of his views, for there are wide differences of opinion on the subject. The Lake is 12 miles across at its widest part, and 40 miles long, though it used to be 10 miles longer, this distance now being filled up by material deposited by the Rhone. There is clear evidence that the Rhone glacier once extended to near Lyons, giving it a length of over 100 miles, with a width, at Geneva, of about 100 miles, and, from the groovings on the mountain sides of the valley, the ice must have been about 5,000 feet thick, varying, of course, and diminishing towards its lower extremity. Such a mass in motion must have had a prodigious eroding effect upon the underlying rock, which is soft. The greatest depth of the lake is about 1,000 feet, and it shallows towards the outflow. A thousand feet seems a great scooping-out, but, plotted on a true scale, the depth of the lake compared with the length, is altogether insignificant, the ratio being about 1 to 260.

Lakes are most common in the much glaciated portions of the globe—North America, Scandinavia, Finland, and Great Britain. [The most characteristic lakes of these regions were described, also their accompanying glacial phenomena, detailed attention being paid to those of the British Isles.] Lakes are not confined to the land. The salt-water lochs or fiords, which abound on the west coast of Scotland, are all in rock-bound basins. They are the continuation of the land valleys below the sea level, and everywhere yield evidence of having once been filled with ice. As a general rule they are shallower at their mouths than further inland.

The sea cannot have made these lochs, which have been scooped out by ice, and now contain sea water because the mouth of the fiord reaches down to the sea level. Loch Etive is a good example. It is 20 miles long, and the mouth is so shallow that as

the tide falls it breaks into a line of foam across the rocky ridge which forms the outlet of the loch, and comes quite close to the sea level, whereas, inland, the basin is in places 450 feet deep. Were the west coast of Scotland to be raised 600 feet, the coast-line would be pushed many miles further west, and many of the lochs, now open to the sea, would become large fresh-water lakes. These fiords, and their deepest parts, occur just where by the glacial theory of their origin, they might be expected.

As all lakes are now in process of destruction, it is interesting to speculate as to where the lakes of the future may be found. Probably countries like Greenland, when the climate becomes less rigorous, and the ice disappears, will reveal a land surface, with numerous lakes, in scooped-out rocky basins.

Though strongly in favour of the origin of the majority of lakes by ice-erosion, I may point out that many distinguished geologists are opposed to this theory, and among them Professors Bonney and Marr. Those interested in the subject may be referred to "Ice Work" by Bonney, and to "The Scientific Study of Scenery," by Marr, for the opinions of those opposed to the theory. For the views of those in favour, the works of Ramsay, of Archibald and James Geikie, and others, may be consulted.

In proposing a vote of thanks to Mr. Whitmell, Professor Kendall expressed a general adherence to the ice-origin of lake basins, and Dr. Forsyth, in seconding, said that a long acquaintance with the lakes of Scotland, and the evidences of glacial action, left no doubt in his mind that they were of glacial origin.

"CANNEL AND ITS AFFINITIES."

Abstract of Paper read by MR. STANLEY NETTLETON, *November 19th,* 1909.

After reviewing the two prevailing theories as to the formation of ordinary coal, "driftwood" and "in situ," and pronouncing in favour of the latter, Mr. Nettleton suggested that cannel has an origin different from ordinary bituminous coal or anthracite, because molluscan and fish remains frequently occur in it, nor is there any apparent definite relation between cannel and the underlying strata such as is found in the case of an ordinary coal seam, and all cannels contain a much higher percentage of ash than bituminous coal.

It seems probable that whilst coal consists of the remains of vegetation which flourished on the spot where the seams are now, cannel may be derived from material which reached its present position in a manner akin to the "bog burst," by which large

masses of semi-decayed vegetation, full of moisture, break away and devastate large tracts of country in Ireland at the present day. Though ultimate analysis may reveal much in common between cannel and ordinary coal, the exact percentage of carbon and hydrogen does not yield definite information as to how either will behave on being subjected to destructive distillation. Much depends upon the combination of those two elements. This is well illustrated in coking, as two coals which have almost exactly similar compositions, may produce cokes of widely different character. Presuming that cannel originally existed as a vegetable "slush," this must have been in a more or less advanced stage of decomposition when deposited upon the sediments of the coal measures. These shales and sandstones would then contain two classes of organic material, one of which would be decomposed before being covered by sediment, the other buried as practically fresh wood.

The distillation products of cannel more closely resemble those of oil shale than those of coal. Each yields gas, but, whilst coal produces tarry compounds, cannel gives materials of the paraffin class.

The seam known as the Adwalton Stone Coal furnishes most of the cannel obtained in Yorkshire, though it is only now worked in two or three collieries. It is in the Middle Coal Measures, about midway between the Haigh Moor and Silkstone seams, and has been worked in years gone by at many collieries in the parishes of Morley, Batley, Dewsbury, and Ossett. It usually contains both coal and cannel, the latter appearing to be a lenticular bed thinning out to the north, south, and east. The lower part of the seam is an inferior cannel, known as "hubb." Taking the section exposed at Roundwood as typical, one may assume that at the period during which cannel was found, the district was occupied by sandbanks of irregular character, varying in thickness over short distances. The history of the seam, which usually contains three and sometimes four distinct qualities of coal or cannel, was probably somewhat as follows. A normal type of seatearth or underclay was covered with rank vegetation, similar to that which a short (geologically) time previously had produced the Silkstone seam of coal, and a little later furnished material for the Haigh Moor seam. On higher ground in the vicinity were great bogs, from which there were from time to time outbursts of semi-rotten vegetable matter. The movement of this material in some instances would displace the coal-forming vegetation growing and decaying on the spot, and material for a true cannel would remain. In some cases there was a mingling of the two classes of matter, and the quantity of cannel in the blend was determined by the extent to which decomposition had advanced before the succeeding beds were deposited. The earliest outflows or bog-bursts came to rest on a land surface, and

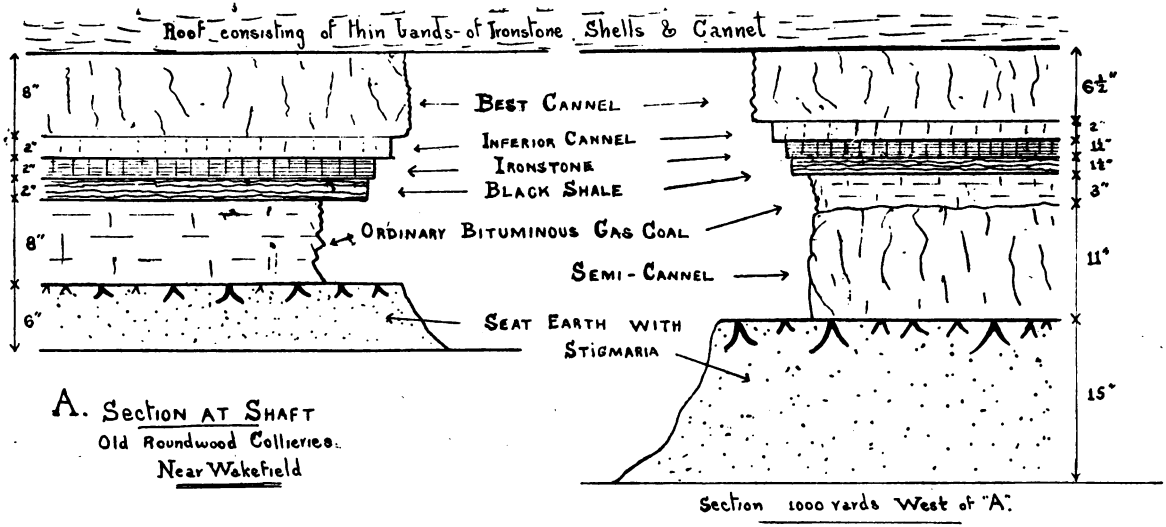


DIAGRAM TO SHOW RE-PLACEMENT OF BITUMINOUS GAS-COAL BY SEMI-CANNEL.

as the amount of material was not large, nor of a very liquid character, irregular patches of cannel were eventually produced. Occasionally it came into contact with the soil in such a manner that sand became mixed with the decaying vegetation. On the recurrence of more settled conditions, the coal plants flourished again, until the surface again sank beneath water level. There was a certain amount of iron in solution in the water, which the plant remains tended to precipitate, forming a band of ironstone, which contains 24 per cent. of iron, 28 per cent. silica, 9 per cent. alumina, and 3 per cent. lime, the balance being loss on calcination, and combined moisture. A black mud was then deposited in shallow water, which was inhabited by fish and molluscs. After this was a bog-burst on a large scale, which swept up everything with which it came in contact. A few trees were entombed in the mass, but plant remains in the cannel are very rare, except on the boundaries of the deposits, though fish remains are fairly common. The material was in such a liquid condition that its constituents had a tendency to classify themselves according to their specific gravity, which in cannel and oil-shales is governed by the quantity of mineral matter present. Hubb, which forms the lower three inches of the seam, contains 44 per cent. of ash, whilst the seven inches of cannel overlying it contains 10·8 per cent. After the main portion of the Adwalton seam was laid down, aquatic conditions prevailed for some time, as the overlying strata for many feet are largely composed of the remains of shells. Mingled with the bands of ironstone and shells there is much cannel-like material, which decreases in quantity with the increase in distance from the main deposit, suggesting that the rising waters were washing down fragments of bog that had been left when the main " burst " took place. The shell band has a remarkable resemblance to hubb in chemical composition, though its physical appearances are so dissimilar. The quantity of organic material in the mud gradually decreased and at a distance of 4 or 5 feet from the main body of cannel the beds have changed from a mixture of shells and cannel to a hard grey shale.

" FOSSIL PLANTS."

Abstract of Paper read by MR. WM. HEMINGWAY, *May 6th,* 1910.

There are indications of a flora in pre-Devonian times, but these are so imperfect that little or nothing is known as to the nature of the plants, though most investigators are disposed to regard them as being similar to the sea-weeds. In the Devonian rocks there are remains of a distinctly land flora, consisting of five principal families—the Calamaria, or proto-calamites ; the Pteridospermæ, or fern-like seed bearing plants ; the Lycopods, or lepidodendron group ; the Cordaitæ, which include the so-called conifers ;

and the Psilophytæ of Dawson, about which very little is known. These show that in the first glimpses we get of a land flora, the evolution of plant life has advanced to a considerable degree. The stock has been differentiated into the four great families which play such a large part in the vegetation of later periods. The common stock from which these families have been evolved must lie far away back in pre-Devonian times, and in all likelihood is for ever lost to us.

Coming to the great Carboniferous rock system, Mr. Hemingway proposes to transform the name to Carbonian, thus bringing it into conformity with the accepted terminology of to-day. This Carbonian system is to include all the rocks, from the Peakian, or Millstone Grits, to the Radstockian series of Somerset and elsewhere in Britain, and the Stephanian series of the Continent. It has numerous sub-divisions. In the vicinity of Leeds there are only two of these which need be mentioned—the Lanarkian and the Westphalian series. In the former is the well-known Halifax hard coal, with its petrified plant remains, and in the latter are numerous impressions of plants in the shales and other rocks associated with the coal seams. Fossil plants with their internal structure preserved, appear to have been first noticed by Witham, and afterwards by Binney, Williamson, Spencer, and others, whilst at the present time their investigation is being carried on by Scott, Kidston, Arber, Olliver, and many others. The results have revolutionised our ideas of botany. The Coal Measure period used to be called the age of ferns. It was further suggested that the major portion of the vegetation of to-day was in direct evolutionary descent from the Carbonian ferns, and that our present ferns have come along the line almost unchanged from pre-Carbonian times. Recent discoveries in fossil botany have demolished this theory, and have established the fact that the majority, if not all, of the Carbonian fern-like plants were not ferns at all, but a singular group of synthetic plants which produced as fructifications both microspores and true seeds. These plants are wonderfully fern-like in the appearance of their foliage ; nor does the resemblance stop here. The microspores were produced in tiny capsules, arranged on the edges or back of the leaves, in a manner closely simulating the spores of a true fern. From the resemblance of the leaves and the male fructification to fern fronds and spores, and the distant resemblance of the female fruits to cycads, they were named Cycadofilicas by Potonie, but, as this implies an affinity to ferns and cycads which may not exist, the tendency is to abandon it in favour of names of a noncommitive character. The idea that ferns are an ancient family of plants must now be abandoned. True ferns have no existence in Carbonian times, but only appeared at a comparatively late period.

The main object of the paper was to incite interest in the

study of fossil plants, which is one of the most interesting and fascinating branches of science. In other branches the student may plod on for a life-time without bringing to the notice of the world a single new species, whereas in this one new species are constantly being recorded. (During the past 25 years Mr. Hemingway has averaged finding one per year, and has still others waiting description).

The greater part of the material from which these plant structures are obtained comes from the Halifax hard coal, the best from its northern outcrop from Huddersfield to Burnley, Littleborough, Deighton, Towneley, and Colne being famous localities. It is found in the coal seam in the form of roundish masses, which are portions of the coal transformed by chemical action into carbonates of lime and magnesia, such change having taken place before the plants forming the coal had fully decayed. Most specimens show more or less the effects of decay, but occasionally examples are found in which the tissues are as perfect as in a recent plant. Thin slices of the material are cut with a lapidary's diamond wheel, then cemented to slips of glass, and ground as thin as possible. A fine collection of these prepared sections was exhibited under microscopes. These plants found in the coal balls of the Halifax bed represent the plants which actually produced that bed of coal, and there is little doubt that those which produced other seams were of a similar type. For many years attempts have been made to correlate these structure plants with those found in the Coal Measure shales, and the small number which could be so correlated was for a long time a puzzle. It finally has been demonstrated that with but few exceptions the two sets of plants are totally different. The structure plants represent the swamp flora of the period, and the plants imprinted in the shales represent the flora of the uplands, brought down by the streams, and deposited along with the mud and sand.

REFERENCES :—

Many of the plants exhibited or mentioned by Mr. Hemingway are described by Dr. Kidston in the Transactions of the Royal Society of Edinburgh, and in vol. xiv. of the Proceedings of the Yorkshire Geological Society, which contains some admirable plates.

"THE ORIGIN OF THE TRIAS ROCKS OF ENGLAND."

Abstract of Paper read by PROFESSOR P. F. KENDALL, M.Sc., F.G.S., *January 21st*, 1910.

These rocks cover a considerable area of the country, and have three essential divisions—Keuper Marl, Keuper Sandstone, and Bunter Sandstone—the sandstones being very red and the marls red or green. Associated with the marls are deposits of gypsum and rock-salt. The redness of the sandstones, though superficial on the constituent grains, is original, and not due to oxidisation—since exposure of the rocks to the atmosphere. Specimens from deep bore-holes are quite as red as those from surface exposures. The mode of formation of such a group of rocks, in which fossils of any kind are extremely rare, raises questions of great interest. Many years ago, Ramsay insisted upon the desert origin of these red rocks, and now that present desert conditions are more studied, much light has been thrown upon the history of these rocks, and it is the opinion of most geologists that they have been formed under conditions similar to such as prevail in some desert regions of the world to-day.

There is a distinct difference between sand grains due to water action, and those due to wind action. The former are irregular in shape, as the friction to which they are subject is not so violent or rapid as in the case of wind-borne grains. These latter are not influenced by the buoying up of surrounding water, nor have they a pellicle of liquid to diminish friction. Desert sands are wonderfully rounded and exquisitely polished, and the grains in the Triassic sandstones are of this type, and the current-bedding is alleged to be that characteristic of wind rather than of water accumulation. That these masses of sandstones have been accumulated by wind is further proved by the nature of the ripple-marks. These may be produced either by wind or water, but they are rarely caused by water on steep slopes, and when they are, they are extremely irregular. On the other hand, ripple marks produced by wind on the steep gradients of sand-dunes are very long and regular in form, and such are said to be common in the Triassic sandstones. The regular grading of the grains as to size also shows an agreement between these sandstones and wind-accumulated sands. So that these sandstones have all the characteristics of deposits due to the action of the wind, similar to what are found now in desert regions. But the aqueous deposits, the marls, rock-salt, and gypsum have to be accounted for, and they fit in very well with the desert theory, or, rather, a desert region through which flowed a river, at periods torrential, at other times dried up. This will also account for the great pebble beds of the Trias.

Similar conditions are seen in South Africa, where are many deep channels excavated by streams, their beds full of large torrent-borne stones. During the dry season sands are blown in, and obliterate these. In the next wet season the streams excavate other channels, thus by recurring excavation and in-filling, deposits consisting mainly of blown sands, and gravel, cover large tracts of country. The river water contains various salts in solution, which are deposited upon the evaporation of the water. In the hollows amongst the sand-dunes water remains, even sometimes during the dry season, and mud is deposited, thus holding up the water. If this evaporates, the salts would be deposited. The mud would crack on drying, and would receive the imprints of animals coming to drink, also raindrops and runlets of water. Sand blowing upon these would preserve the markings impressed upon them. These pools may remain sufficiently long enough to become the abode of animal and plant life, and some of them in South Africa swarm with a small crustacean known as Estheria. All these phenomena are reproduced in our Triassic rocks. The great masses of what was once blown-sand have their hollows filled in with deposits of rock-salt, gypsum, and marl, the latter containing impressions of sun-cracks, raindrops, ripple-marks, and foot-prints of various animals, with, in some cases, fossils, the commonest of which is Estheria. The pebble deposits are also well represented, and afford evidence of the direction from which the rivers flowed, for there appears to have been two of them. The pebble beds north of the Bristol Coalfield contain rocks which have apparently been brought from the north-west, whilst in the famous beds at Budleigh Salterton, where the pebbles are very fossiliferous, practically all the fossils are of non-British types, but are exactly the same as are found in the Ordovician and Devonian rocks of Normandy. This type of pebbles is traceable through the Midlands to Nottingham, while another series probably originating in some northerly direction extends through Lancashire and Cheshire joining the southern series in the Midlands. The pebbles dwindle away in a north-easterly direction and practically disappear in about the latitude of Doncaster.

REFERENCES :—

This subject has received much attention during the past few years. Those desiring further information upon it are referred to the Reports of the British Association, 1906–7–8–9 ; also to two papers, and report of discussion in Proc. Yorks. Geol. Society, Vol. XVI., pt. 1.

"REEF KNOLLS."

Abstract of Paper read by MR. ERNEST PARSONS, B.Sc., *March 18th,* 1910.

Certain conical hills in the Clitheroe and Craven districts were described. These were first called "reef knolls" by Mr. R. H. Tiddeman, then on H.M. Geological Survey, who wrote of them—"The form and system of arrangement of these white limestones (hills) are peculiar. The stratification is usually somewhat obscure, and the masses rise in the form of conical or ovoid eminences, up to a height of 300-400 feet. The change in the thickness of these limestones occurs in a very limited horizontal extent. These eminences ordinarily present upon their sides strata which dip away from the mass in all directions, but when the rock is quarried, or denuded by atmospheric agencies, one sees that the stratification, rough as it is, preserves its horizontality, or agrees with the direction of inclination of the surrounding rocks. At the foot of these hills in many places there is a breccia, formed of fragments of the Lmestone which have broken off the reef, above and beneath wind and water, and have subsequently been covered up by the mud of the Bowland shale and compacted into a breccia. Fragments of limestone similarly consolidated occur (though more rarely), on the sides of the knolls themselves."

The origin of these features has given rise to much discussion. Mr. Tiddeman believes them to have been built up by marine organisms in a slowly sinking area, very much as coral reefs have. The nature of the rock, the abundance and perfect preservation of the fossils, the dip, and the breccias at the foot, support this hypothesis. On the other hand, Dr. J. E. Marr, of Cambridge, argues that they are due to movements in the crust of the earth. He says that "Between the comparatively rigid Millstone Grits above and the lower Palæozoic rocks below, lie the more yielding group of limestones and shales above these. The formation of the folds with north-easterly and south-westerly axes must have resulted in the accumulation of the rigid Millstone Grits above in great masses into the synclines, and their dragging away from the tops of the anticlines. There may have been actual rupture of the grits of the arches, but in any case there would be relief of pressure there, causing the limestone to be squeezed out from below the synclines, and to accumulate in the anticlines, and I believe that it is in this way the 'knoll reefs' were formed, while the minor faults, which would inevitably accompany repetition of the strata, are marked by breccias, differing in character according to the nature of the rocks in which they were formed." Dr. Marr believes that the relief from pressure in the anticlines may account for the preservation of the fossils in the knolls.

Mr. Wilmore recently has endeavoured to prove that the hills are due to the crossing of two series of folds at right angles.

Mr. Parsons has devoted considerable time to the examination of some of these hills, in the hope of throwing more light upon their mode of formation. As against Dr. Marr's theory, he points out that in the Grassington district, where are several fine examples of these knolls, the rocks are only very slightly folded, and faults are almost absent, whereas in the Draughton and Bolton Abbey area, which is cited by Dr. Marr in favour of his theory, and where the rocks are highly contorted, and much faulted, there are no hills with the characteristics of " reef knolls." A diligent search around Stebden, one of the best examples, revealed no signs of overthrusting or faulting, nor have any been found in the neighbouring knolls. The only sign of earth movement in the area was in the thin black limestone bands of Thorpe Fell, where in the beck behind Cracoe the junction between two limestone bands appeared to be slickensided, and calcite developed in the line of the thrust, but, within a yard on the same horizon, all traces of movement had disappeared.

In Stebden the quaquaversal dip is undeniably present. The slopes are undoubtedly dip slopes, and although in a few exposures the dip is not so evident, still excavations showing good dip slopes are present on all sides of the hill. Mr. Dakyns has recorded a dip of 53deg. into the hill on the South side, but a very careful search does not confirm this. There is a swallow-hole at the foot of the hill, around which the limestone has slipped, and it may be that this dip has been erroneously taken from one of the slipped blocks. The breccias recorded by Mr. Tiddeman are difficult to find in this area. There are none visible on the flanks of Stebden, nor in the shales in the beck by that hill, Elbolton and Thorpe. Another noteworthy fact is that the dips are much steeper on the north side of the hill, than on the south, a further evidence of the reef origin of the knolls, as was seen by a diagram. An attempt to bring out the bedding in hand specimens of the limestone, by means of the action of dilute hydrochloric acid, was not successful, but it was noted that the fossils are apparently arranged in definite directions, and the crinoid stems lie parallel to the bedding. The form of the hills (Skelterton, Butterhaw, Stebden, Elbolton, Keal Hill, Thorpe, and Hartlington), their situation, the composition of the limestone, and the nature of the fossils, were further adduced as arguments in favour of these hills being due to the accumulations of organic remains, rather than to earth movements.

REFERENCES :—

A paper by Dr. J. E. Marr, Q.J.G.S., vol. 55, 1899, puts forth his views upon the origin of these hills, and quotes from the observations of Mr. Tiddeman and others. A paper by Mr. A. Wilmore on " The Structure of some Craven Limestones," in Proc. Yorks. Geol. Society, vol. 16. pt. 2, deals with the subject, and contains a bibliography.

NOTE ON A SECTION IN THE MEANWOOD GANISTER QUARRY.

(*In explanation of accompanying plate*). ALBERT GILLIGAN, B.Sc.

For many years the working of this quarry has provided much of interest to local geologists. A detailed description of the section is published in part 8 of the Transactions of the Association, in part 7 (p. 29) there are some conjectures as to the origin of the drift overlying the Ganister Beds, whilst in part 7 (p. 51) there is a photograph and description of the finest specimen of the numerous fossil trees found in the quarry from time to time. The quarry is in the Ganister Beds of the Lower Coal Measures. The beds are very much contorted. The variations in the contortions exposed in the working have been at times very striking, and it is satisfactory to know that Mr. Godfrey Bingley has a series of about 40 photographs showing these from 1891 to 1909. In the latter year the working on this side of the quarry had to be abandoned owing to the broken strata, and the plate depicts the section then exposed, which will soon be covered up.

The photograph shows a monoclinal fold in the beds. It will be seen that the grit has been much shattered on the steep limb of the fold, and assumes a somewhat massive appearance to the east. The topmost bed of the grit seen in the syncline ends in a rounded broken mass in the east, showing some indication of overfolding due to the thrusting movement which acted from the west. A thick bed of shale, now converted into clay, fills in the hollow of the fold, and encloses the broken end of the topmost bed of grit above mentioned.

Photo.—CODFREY BINGLEY.

Section in GANISTER QUARRY, MEANWOOD VALLEY, LEEDS,

Looking N. of W. *June 16th*, 1900.

REPORTS OF EXCURSIONS.

By E. Hawkesworth.

Otley.—June 17th, 1908 (evening). Leader, Mr. G. V. Wilson. The object of the excursion was to visit a section in the Clifton Beck, about a mile north of Otley, which shows a marine band in the Millstone Grit. The section is fully described by the leader, and list of fossils given, in Proc. Yorks. Geol. Society, Vol. XVII., pt. 1.

Grassington and District.—July 11th, 1908. Leaders, Messrs. A. Gilligan, B.Sc., and G. V. Wilson. The main object of the excursion was to examine the remarkable effects of the cloud-burst on Barden Fell, but heavy rain coming on prevented this being done. They have been described by Mr. Gilligan in Proc. Yorks. Geol. Society, Vol. XVI., pt. 3. Many examples of the damage done by this cloud-burst were noted in the valley of the Eller Beck, on the railway journey from Skipton to Rylstone. Leaving the train at the latter place, the party walked through Cracoe, and spent some time in examining the section exposed in a gill behind the village. Here the upper beds of the Carboniferous Limestone, containing fine fossil corals, were overlaid by shales and limestones of the Pendleside series, from which a number of fossils, including *Pterinopecten papyraceus*, *Posidoniella laevis*, *P. becheri*, and *Goniatites*, were obtained. The pieces of beautifully weathered-out encrinital limestone in the walls were much admired. Walking along the slopes of the fell, great spreads of gravel and boulders brought down by the torrents caused by the cloudburst, were seen in several places, showing graphic examples of the great transporting power of a sudden rush of water of high velocity on a steep gradient. Some good collections of Carboniferous Limestone fossils were obtained from Thorpe Fell and Elbolton, where they are not only plentiful, but exceedingly well preserved, and easy of extraction. Those found included *Bellerophon*, *Orthoceras*, *Goniatites*, *Productus*, *Spirifer*, many corals, and a few trilobites.

Clapham.—September 5th, 1908 (Y.N.U.) Leader, Professor T. Mc Kenny Hughes, M.A., F.R.S., etc. Going east from Clapham, the first call was made at a gravel-pit on the side of the hill near the Ingleborough Home Plantation, just over five hundred feet above sea-level. The section shows current-bedded gravel, containing a large quantity of stones, some very large, and many of them ice-scratched, all apparently of local origin. There is a similar exposure a little further to the west, and the leader said these puzzled him more than any others of the many and intricate problems of the district. But this was only a 'side-line,' the main object being to examine the sections of pre-Carboniferous rocks so well exposed

at Wharfe Mill Dam, and in the adjacent bed of the Austwick Beck, which show a sequence from the Bala or Coniston Limestone series of the Ordovician (or Lower Silurian of the Geological Survey, through the Silurian (or Upper Silurian), to the Carboniferous. An obscure exposure in the dam yielded some interesting fossils, including graptolites (probably the first to be found in this particular bed), *Illænus*, and *Strophomena siluriana*. The rocks are mudstones and volcanic ash. The amount of water running in the beck interfered somewhat with the examination of the higher beds of the series, but several fossils were found, some of such interest as to warrant being sent to the specialists for identification. A detour was made for a short distance to the north of the beck, for the purpose of inspecting the conglomerate at the base of the Silurian. (The names as used by Prof. Hughes are now used, viz., Ordovician and Silurian). It is here thicker and coarser than anywhere else in the area. The matrix is calcareous, and the included fragments are rolled and angular, of various sizes, derived from the mudstones, grits, and breccias of the Green Slate series. The conglomerate is cut off by a fault, so does not appear in the stream section. Many instructive features were observed on the way up the dale. The variations in elevation of the Silurian rocks were well seen, the beds of hard grit forming the higher points attaining nearly 1200 feet above sea-level, whilst the overlying Carboniferous Limestone fills up the hollows due to the denudation of the softer shales, which near Norber fall to 700 feet. On the slopes of Studrigg the folding of the older rocks were shewn clearly. A call was made to see the bed of an old lake near Southwaite, in which is a bed of marl made up of the remains of freshwater shells. Crummack Beck Head was the next stopping place. Owing to folding and subsequent denudation, the Silurian basement conglomerate is exposed here, and within two or three yards of it is a good section of the Carboniferous basement conglomerate, truly a most interesting spot, but time prevented an adequate study of it. Passing through the fields into Norber Lane, it was possible to follow the line of the famous Norber boulders, as carried by the Crummack Dale glacier, from their source on the outcrop of the Austwick Grits, where they were spread in great profusion, till they gradually assumed a definite trail, towards the summit of Norber Brow, where the perched blocks, so familiar to all geologists, are left stranded on the limestone. We were not able to visit them, but the conglomerate at the base of the Carboniferous Limestone under Norber Brow, was examined. It is here a thick deposit, resting upon the edges of the Bala beds. At its base are some very large pebbles, derived from the under-lying rocks. Higher up these gradually get smaller, and the calcareous matrix contains a number of fossil corals of various species, some of which were collected. From the Bala beds exposed in the lane below specimens of some trilobites (*Trinucleus*) were obtained.

WHITWOOD.—October 3rd, 1908. By the kind invitation of Mr. Isaac Hodges, F.G.S., who acted as leader, a visit was paid to the Whitwood Silkstone Colliery, of Messrs, Henry Briggs, Son & Co., Ltd. The main object of the excursion was to examine sections in the Silkstone seam of coal. This is split into two divisions by shale, which commencing as an extremely thin parting, gradually expands to a thickness of nearly forty feet, and an exploring heading driven about 800 yards proves the seam to re-unite. Those present walked to the extremity of this heading, inspecting the section exposed along its sides. The separation of the seam does not appear to be due to a "wash-out," such as sometimes occurs in the overlying Haigh Moor seam, but is more likely due to some sort of faulting. The heading passed through the Don Pedro 50 yards fault, and the tilting of the coal on each side of the throw was seen. Mr. Hodges entertained those present to tea, and a very cordial vote of thanks was passed to him for his hospitality, and his kindness in giving the Association the opportunity of examining the sections in the exploring heading, which was abandoned a few days afterwards.

FRYSTON.—April 24th, 1909. Leader, Mr. Stanley Nettleton On the way from Castleford station to Fryston, a quarry was inspected, where the bed of sand at the base of the Permian formation is worked extensively. In the overlying Lower Magnesian Limestone, specimens of *Schizodus*, *Bakevillia*, and *Turbo* were found. The large quarries at Fryston, in the same limestone, belonging to Messrs. J. Crowther & Son, were visited, and similar fossils were found. Some fine pieces of beautifully lustrous and transparent selenite were obtained. Mr. H. G. Soar, the manager of the Fryston Colliery, had very kindly put aside for the occasion heaps of shale from the roofs of the Warren House and Silkstone coal seams, which provided work in plenty for those present. The material overlying the former seam is famous for fossil plants, and many beautiful specimens were obtained. In one heap, almost every blow of the hammer revealed a frond or branch of a fern or other plant, in a remarkably perfect state of preservation. Those found were mostly fern-like plants, such as *Neuropteris*, *Alethopteris*, *Mariopteris*, *Dactylotheca*, and *Calamodadus*, whilst in another heap *Siggillaria* and *Lepidodendron* predominated. The Silkstone material provided a profusion of well preserved specimens of *Anthracosia*.

WOODLESFORD.—May 24th, 1909 (evening). Leader, Mr. Isaac Hodges, F.G.S. A visit was paid to the Water Haigh Collieries, now being constructed by Messrs. Henry Briggs, Son & Co., Ltd., who had kindly granted permission. In an excavation being made for the fan-chamber of one of the shafts, a complete section of the Aire Valley alluvial deposits was seen. It consisted

mainly of sand, with a bed of fine clay, though the deposits are exceedingly variable, four sections made within an area of a few yards showing different beds. The tip of material from the sinking of the shafts was examined, and yielded many specimens of *Calamites*, *Alethopteris*, and *Neuropteris*.

MEANWOOD.—June 11th, 1909 (evening). An inspection was made of the sections exposed in Messrs. Rowley's Ganister quarry (see plate and explanation, page 40). Some obscure fish remains were found in the shale overlying the ganister, and from the ganister itself fine specimens of *Lepidodendron*, *Stigmaria*, and *Calamites* were obtained.

INGLETON.—July 17th, 1909. Leader, Mr. E. Hawkesworth. The route followed was that described in L. G. A. Transactions, Pt. XIV., page 45.

SEDBERGH.—July 31st to August 2nd, 1909 (Y.N.U.) Leader, Mr. E. Hawkesworth. On the first day Dove Cote (Douker) Gill was ascended. The results of the great Dent Fault are well seen here, in one place the Coniston Flags (Silurian) abut against the Carboniferous Limestone, the beds of which are highly inclined. A fine section of the conglomerate between the Silurian and Carboniferous systems was also seen in the gill. Nor Gill was then explored. It shows perhaps the most complete section known in the county of the basal Carboniferous rocks. There is a great mass of red conglomerate exposed, which is succeeded by alternations of grey or greenish conglomerate, limestones containing pebbles, and calcareous shales, the detrital material gradually diminishing in quantity as the section passes up into beds of normal Carboniferous Limestone, which are here tilted at a very high angle by the proximity of the Dent Fault. There appeared to be a distinct break between the red and grey conglomerates, and it was suggested that a careful investigation of the section might prove the red rocks to be of Upper Old Red Sandstone age, as similar beds in like positions in Scotland are considered to be, and that the grey conglomerates in the district, and those of the Ingleborough district, are the true basement Carboniferous beds. The second day was devoted to an examination of the volcanic series of rocks in Wandale and Odd Gill, and a visit to Spen Gill, which contains a very good section of the upper beds of the Bala series, and the lower ones of the Silurian. This section is described in detail by Messrs. J. Nicholson and Marr, in Q.J.G.S., Vol. 44, page 654. The wet weather greatly interfered with the day's work. The third day was spent in examining the country between Sedbergh and Dent. A grooved and polished surface of Coniston Grit, on Sedbergh Golf Links, first demanded attention. Its appearance strongly resembled a glaciated surface, but the fact that a thin bed of rock of

somewhat different texture had just been removed off it, for road stone, compelled some other explanation. It was evidently an example of intensified slickensiding, caused by one bed slipping over the other. Several graptolites and other fossils were obtained from the Coniston Flags on Helm Knott. The igneous dyke in Helm Gill was seen, and its influence on the adjacent beds of Coniston Limestone noted. An exposure of the same limestone higher up the gill yielded several fossils.

THE LIBRARY.

The books belonging to the Association are in the care of the Hon. Secretary, who is always glad to arrange for the loan of them to members, on suitable notice being given, and postage, etc., paid.

Besides a number of miscellaneous pamphlets, etc., and a few books, such as Tate and Blake's " Yorkshire Lias ; " Lyell's " Principles of Geology ; " Phillips' " Yorkshire Coast ; " Mantell's " Pictorial Atlas of Fossils ; " the following are received as published :—

" The Naturalist " (monthly).
" The Quarterly Journal of the Geological Society of London."
" The Proceedings of the Geologists' Association " (London).
" The Proceedings of the Yorkshire Geological Society."
" The Transactions of the Yorkshire Naturalists' Union."
" The Transactions of the Liverpool Geological Association."
" The Transactions of the Leeds Naturalists' Club."
" The Transactions of the Leeds Astronomical Society."
" The Transactions of the Manchester Geological Society."
" The Transactions of the Hull Geological Society."
" Journal of the Manchester Geographical Society."
" Memoirs of the Manchester Literary and Philosophical Society."
" British Association Reports."
" Records of the Australian Museum."
" United States Geological Survey—Bulletins, Professional Papers, and Monographs."
" Reports of the Smithsonian Institution."

CASH ACCOUNT, MAY 4th, 1910.

Receipts.				£	s.	d.
Balance from last Account				3	17	10
Arrears of Subscriptions				2	10	0
Subscriptions for 1909–10 :—						
81 Members	20	5	0			
5 Country Members	0	12	6			
9 Associates	1	2	6			
				22	0	0
Sales of Transactions				2	0	0
Bank Interest				0	3	6
				£30	11	4

Expenditure.				£	s.	d.
Printing of Syllabus, Notices of Meetings, etc., etc.				3	14	9
Postages of Syllabus, Notices of Meetings, etc., etc.				3	18	2
Stationery				1	19	3
Insurance of Books				0	2	0
Gas, etc. for Lantern				0	5	9
Yorkshire Naturalists' Union				1	0	2
University of Leeds				2	2	0
Sundries				0	16	2
Temporary transfer to Dwerryhouse Testimonial Fund				0	14	0
Cash in Yorkshire Penny Bank	14	18	9			
Cash in hand	1	0	4			
				15	19	1
				£30	11	4

BALANCE SHEET MAY 4th, 1910

Assets.				£	s.	d.
Subscriptions unpaid				5	2	6
Due from Dwerryhouse Testimonial Fund				0	14	0
Cash in Yorkshire Penny Bank	14	18	9			
Cash in Treasurers' hands	1	0	4			
				15	19	1
Books, etc., Stock of Transactions, Stationery						
				£21	15	7

Liabilities. Nil.

Examined and found correct, W. DENISON ROEBUCK,
Hon. Auditor, 11th July, 1910.

List of Members at end of Session, 1909-10.

Those who have contributed Papers or conducted Excursions are distinguished by an asterisk.*

Honorary Members.

Year of Election.

1886 *Cole, Rev. E. Maule, M.A., F.G.S., Wetwang Vicarage, York.

1886 *Horne, Wm., F.G.S., Leyburn.

1891 *Marr, J. E., D.Sc., F.R.S., Cambridge.

1874 *Miall, Prof. L. C., F.R.S., F.G.S., F.L.S., Letchworth.

1887 *Sollas, Prof. W. J., D.Sc., F.G.S., Oxford.

1890 *Woodward, A. Smith, LL.D., F.R.S., British Museum (Natural History), London.

1996 *Groom, Prof. T. T., M.A., D.Sc., The University, Birmingham.

1907 *Bond, J. W., Torre Road, Burmantofts, Leeds.

Ordinary Members.

1904 Abbott, A., 8, Woodvale Terrace, Horsforth, Leeds.

1907 Andrews, W.A., M.Sc., 11, Roundhay Place, Leeds.

1891 *Bailey, J. W., 2, St. Mark's Villas, Leeds.

1897 Bain, J., The Larches, Rutland Road, Harrogate.

1904 Beahan, J. J., City Engineer's Office, Leeds.

1882 *Bedford, J. E., F.G.S., "Arncliffe," Shire Oak Road, Leeds. (*Past President*).

1889 *Bingley, Godfrey, "Thorniehurst," Shaw Lane, Leeds (*Past President*) (*Member of Council*).

1895 *Bees, W. J., B.Sc., 43, Ash Grove, Leeds.

1908 Booth, Peter, 30, Mexborough Drive, Leeds.

1909 Bowen, David, Mining Dept., The University, Leeds.

1883 *Branson, F. W., F.I.C., 14, Commercial Street, Leeds (*Vice-President*).

1908 Branson, F. H., Wynneholme, Far Headingley, Leeds.

1909 Broadbent, F. J., Croft House, Mirfield.

1904 *Burnet, Arthur, 52, Prospect Terrace, Hunslet, Leeds (*Member of Council*).

1908 Burgess, W. E., B.Sc., 17, Pawson Street, Morley.

1907 Carnes, Geo., Wood View, Beeston, Leeds.

1906 *Cheetham, C. A., Nutting Grove, Farnley, Leeds.

1905 Charlesworth, A., M.Sc., 100, Bankside Street, Roundhay Road, Leeds (*Member of Council*).

1907 Clemishaw, J., 42, Springfield Place, Leeds.

1891 *Clough, S., Micklefield.

1906 *Crowther, Hy., F.R.M.S., The Museum, Leeds.

1890 *Cuttriss, S. W., M.I.E.E., Prudential Buildings, Leeds (*Member of Council*).

1908 Dixon, Wm., City Engineer's Office, Leeds.

1896 Dodgson, Aquila, South Lea, Kirkstall Lane, Leeds.

1907 Duchesne, H., 20, Kelso Road, Leeds.

1896 *Dwerryhouse, A. R., D.Sc., F.G.S., Deraness, Deramore Park, Belfast, (*Vice-President*).

1905 Everett, J. H., B.Sc., 23, Cranbrook Avenue, Beeston Hill, Leeds (*Member of Council*).

1909 Everitt, W. G., East Thorpe House, Mirfield.

1907 Forster, Alex., B.Sc., 11, Savile Place, Chapeltown Road, Leeds.

1891 *Forsyth, David, M.A., D.Sc., 101, Caledonian Road, Leeds (*Past President*) (*Member of Council*).

1907 Foster, Hy., 48, Ridge Mount, Armley, Leeds.

1909 Gill, E., Fold Head, Mirfield.

1907 *Gilligan, A., B.Sc., 5, Ash Grove, Leeds (*Member of Council*).

1907 Grant, C. H., M.Sc., F.R.Met.S., 212, Burley Road, Leeds.

1893 Hanbury, Chas., 1, Park Place, Leeds.

1907 Hart, Geo. A.. City Sewerage Engineer, Leeds.

1901 Hastings, Geoffry, 15, Oak Lane, Bradford.

1886 *Hawkesworth, Edwin, " Sunnyside," Crossgates, Leeds (*Past President*) (*Hon. Secretary*).

1890 Heaton, Hy., " Cot Field," Roundhay, Leeds.

1908 Henzell, Chas. G., City Waterworks Engineer, Leeds.

1906 Hewitt, R. G., B.Sc., Faire View, Birkby Hall Road, Huddersfield.

1875 *Holgate, Benj., F.G.S., " The Briers," Roundhay, Leeds (*Past President*).

1906 *Hodges, Isaac, F.G.S., Woodlesford, near Leeds.

1905 Hornby, John, St. Jude's School, Hunslet, Leeds.

1889 *Howarth, J. H., J.P., F.G.S., " Somerley," Halifax.

1907 Hummel, E. L,. B.Sc., 152, Woodsley Road, Leeds.

1886 Kay, Stanley R., High Mead, Wood Lane, Headingley, Leeds.

1891 *Kendall, Prof. P. F., M.Sc., F.G.S., " Rose Dene," Weetwood, Leeds (*Past President*) (*Member of Council*).

1909 Kendall, Percy, " Rose Dene," Weetwood, Leeds.

1906 Keighley, L., 5, Sefton Terrace, Beeston Hill, Leeds.

1893 *Lang, J., 8, Roundhay Place, Harehills Lane, Leeds.

1907 Lowther, J. A., B.A., 26, Hessle Terrace, Leeds.

1908 Margerison,, Saml., Grey Gables, Calverley, Nr. Leeds.

1908 Marsden, Oliver, 7, Regent Terrace, Hyde Park, Leeds.

1907 Millar, J. E., 23, Mentone Place, Leeds.

1889 Mitchell, F., 9, Upper Fountaine Street, Leeds.

1907 Murray, R., The Manor House, Barwick-in-Elmet, Leeds.

1903 *Nettleton, Stanley, Roundwood, Ossett (*Member of Council*).

1909 Oswald, Miss E. M., Girls' Grammar School, Bradford.

1895 *Parsons, W., F.R.G.S., Lyndhurst, North Grange Road, Headingley, Leeds (*Member of Council*).
1907 *Parsons, E., B.Sc., 13, Colville Terrace, Leeds.
1990 Parry, Miss Ethel, 5, Marlborough Gardens, Leeds.
1908 Pickering, G. F., Gauroyd House, Horsforth, Leeds.
1909 Pickles, H., B.A., B.Sc., 5, Brudenell Mount, Leeds.
1874 Pocklington, H., 11, Regent Park Terrace, Leeds.
1909 Poole, Granville, B.Sc., 45, Young Street, Doncaster.
1902 Price, A., 16, Northfield Terrace, Wakefield.
1907 Price, J. W., North Terrace, Crossgates, Leeds.
1908 Reason, Sydney, The Outwood, Horsforth, Leeds.
1881 Roebuck, W. Denison, F.L.S., 259, Hyde Park Road, Leeds.
1909 Rogers, Miss B. B., 22, Manor Terrace, Headingley, Leeds.
1887 *Rowley, Walter, F.S.A., F.G.S., Alder Hill, Meanwood, Leeds.
1904 Robinson, W. J., 54, Cardigan Lane, Leeds.
1908 Shaw, C. H., Purlwell House, Batley.
1905 Smith, H., 7, Edwin Road, Leeds (*Member of Council*).
1906 Stephenson, H. L., 73, Colwyn Road, Leeds.
1909 Sunderland, W., 2, Hovingham Terrace, Harehills Lane, Leeds.
1902 *Thompson, Prof. G. R., B.Sc., F.G.S., "North View," Park Lane, Roundhay, Leeds (*Member of Council*).
1906 Thornber, W., Oxford Chambers, Victoria Square, Leeds (*Member of Council*).
1909 Tickle, Gilbert Y., 307, Fulwood Road, Sheffield.
1906 Turner, F., 34, Wesley Street, Morley.
1904 Walbank, Wm., "Pickrin Lodge," Halton, Leeds.
1908 Walker, Arthur, 1, Headingley Mount, Kirkstall Lane, Leeds.
1908 Ward, Jas. E., Hanover Square, Leeds.
1897 *Whitmell, C. T., M.A., B.Sc., "Invermay," Hyde Park, Leeds (*President*).
1905 Whitmell, Mrs. C. T., "Invermay," Hyde Park, Leeds.
1906 *Wilson, G. V., B.Sc., Arthington Road, Pool, near Leeds.
1909 Wills, Albert E., Denby Villas, Knowle Road, Mirfield.

Country Members.

1883 *Brownridge, Lieut. Colonel Chas., F.G.S., M.I.C.E., 21, Willowbank Road, Birkenhead (*Past President*).
1889 *Carter, W. Lower, M.A., F.G.S., 11, Twyford Avenue, Acton Hill, London, W.
1886 Crowther, J. A., Borough Engineer, Southampton.
1904 *Edwards, E. J., M.Sc., 19, Deri Road, Roath, Cardiff.
1906 *Johns, Cosmo, M.I.M.E., F.G.S., Burngrove, Pitsmoor Road, Sheffield.
1908 Jukes-Browne, A. J., B.A., F.G.S., Floriston, Torre, Torquay.
1890 Stephenson, W. E.
1889 Wilkinson, Jno. J., Burnside, Skipton.

Associates.

1909 Chapman, Miss S. E., Geological Dept., The University, Leeds.
1908 Charlesworth, Jno. K., c.o B. Walmsley, Brudenell Road, Leeds.
1908 Davison, Miss Irene E., 10, Providence Avenue, Hyde Park, Leeds.
1908 Gould, P., Geological Dept., The University, Leeds.
1908 Guy, Ernest S., Beverley Terrace, Dewsbury Road, Leeds.
1908 Haigh, Jno. H., 28, Pynate Road, Batley.
1908 Kay, Stanley B., High Mead, Wood Lane, Headingley, Leeds.
1908 King, Wm. N., 25, Dawson Road, Beeston Hill, Leeds.
1908 Parr, T. A., 62, Bromhill Terrace, Batley.
1908 Nicol, Miss Agnes, The Avenue, Halton, Leeds.
1908 Smith, Sydney, 107, Belle Vue Road, Leeds.

Thirty-Seventh Session, 1910-11.

Officers:

President: C. T. WHITMELL, M.A., B.Sc.

Vice-President: F. W. BRANSON, F.I.C.

Hon. Secretary and Treasurer: E. HAWKESWORTH, Sunnyside, Crossgates, Leeds.

Members of the Council.

GODFREY BINGLEY.
ARTHUR BURNET.
A. CHARLESWORTH, M.Sc.
C. A. CHEETHAM.
S. W. CUTTRISS.
J. H. EVERETT, B.Sc.
D. FORSYTH, M.A., B.Sc.
A. GILLIGAN, B.Sc.
Professor P. F. KENDALL, M.Sc., F.G.S.
STANLEY NETTLETON.
W. PARSONS, F.R.G.S.
HENRY SMITH, F.I.P.S.
Prof. G. R. Thompson, B.Sc. F.G.S.
W. THORNBER.

Sale of Back Parts of the Transactions.

The Transactions of the Association contain a store of valuable geological information. Most of the subjects are dealt with at length, and the reports of excursions will be very useful to members visiting the localities described. *Part* 14 *contains a classified index of parts* 1 *to* 14. Parts 1 and 10 are now out of print, and the stock of some of the earlier ones is very limited.

Parts 2 to 14, except part 10, containing over 700 pages—to members and associates, 7/-; to non-members, 10/-; postage 6d. extra.

Separate parts for those desirous of completing their set: 2, 4, 11, 12—6d. each to members and associates; 9d. each to non-members.

3, 5, 6, 7, 8, 9—9d. each to members and associates; 1/- each to non-members.

13—1/- to members and associates; 1/6 to non-members.

14—2/- to members and associates; 2/6 to non-members.

Postage extra.

Leeds Geological Association.

THE OBJECT OF THIS ASSOCIATION is to promote the study of Geology by means of field excursions, exhibition of specimens, reading of papers, and discussions.

MEETINGS are held on the **third Friday in each month** (except when otherwise stated), from October to May, in the **Geological Department of the University of Leeds (Entrance 22, De Grey Road), at 7.30 p.m.**

EXCURSIONS are made frequently to places of Geological interest.

The Association is affiliated with the **YORKSHIRE NATURALISTS' UNION**, which constitutes each member an Associate of that Union, and as such, entitled to attend all its Meetings and Excursions.

A volume of **TRANSACTIONS** is published occasionally, and issued free to Members and Associates.

Terms of Membership.

ORDINARY MEMBERS' Subscription, **5/-** per annum.

COUNTRY MEMBERS (residing 20 miles or more from Leeds), Subscription **2/6** per annum.

ASSOCIATES.—Assistant Teachers in the Schools of the City, Students in attendance at Geological Classes, and others as the Council may determine, may become Associates, Subscription **2/6** per annum.

Country Members and Associates receive the Transactions as published, but do not receive separate notification of each Meeting and Excursion.

All Subscriptions are DUE IN ADVANCE on JULY 1st in each year.

Members are invited to bring specimens for exhibition at any of the Meetings, or to report any matter of Geological interest which may come within their cognisance.

Members may introduce their friends (ladies and gentlemen) at the Meetings and Excursions.

Members are requested to at once notify the Hon. Secretary of any change of address.

Hon. Secretary and Treasurer—
E. Hayden Swift, Sandringham, Cross Gates, Leeds.

CONTENTS

Annual Report, 1908–9 [illegible]

Radioactive Elements and Geology—Bonney [illegible]

Recent Deposits in Australia—Tate and [illegible] [illegible]

Some Rockbottle Masses in Gneiss, near Kimbriant—Hawkesworth (with plate) [illegible]

The Applications of Geology to Public Works Construction—H. Lapworth [illegible]

Geological and Biological Changes in Lake of Tiberias—Kendall [illegible]

The Glacial History of Holderness—Sheppard [illegible]

References to the subjects of other papers read [illegible]

Annual Report, 1909–10 [illegible]

The Origin of Lakes—Whitwell [illegible]

Enstatite and its Alteration—Anderson (with section) [illegible]

Fossil Plants—Hemingway [illegible]

The Origin of the Tors—Bonney [illegible]

Red Scoriæ—E. Parsons [illegible]

Note on a Section in Stonywood Quarry—[illegible] [illegible]

Report of Excursion to Otley [illegible]

[illegible] Cressington and Tinsper

[illegible] Clemson

[illegible] Whitwell

[illegible] Parsons

[illegible] Woodhead

[illegible] [illegible]

[illegible] Lapworth

[illegible] Anthony

The Infinity [illegible]

Balance Sheet, 1909–10 [illegible]

List of Members [illegible]

Officers, 1910–11 [illegible]

Proceedings of Local Society of Literature [illegible]

Terms of Membership [illegible]

Science Library
QE
1
.L48
v.4
pt.16

THE

TRANSACTIONS

OF THE

:: :: LEEDS :: ::
GEOLOGICAL ASSOCIATION

PART XVI.

:: 1910-11 ::

:: Edited by the ::
Honorary Secretary

Price 2/-

Members may purchase extra copies at 1/6 each, postage extra.

UNIVERSITY OF MICHIGAN LIBRARIES

THE TRANSACTIONS

OF THE

LEEDS

Geological Association.

PART XVI.

:: 1910-11. ::

EDITED BY THE HONORARY SECRETARY.

LEEDS:
NUTT & CO., LTD., PRINTERS.

Issued December 7th, 1911.

Science Library
QE
1
.L48
v.4
1911/12

CONTENTS

	PAGE
Annual Report, 1910-11	3
Balance Sheet, 1910-11	7
The Iron-ore Deposits of Lapland—Nettleton	8
The Formation of Cavities in the Magnesian Limestone—Guy ...	10
The Cleveland Dyke—King (*with plates*)	16
Alluvial Deposits at Woodlesford—Gilligan and Hummel	24
The Lithology of the Millstone Grits—Pickering	27
Note on Permian Boulders at Rothwell Haigh—Hawkesworth (*with plate*)	31
Report of Excursion to Ardsley	32
" " Brimham Rocks	32
" " Ilkley	35
" " Clapham	35
" " Rothwell Haigh	35
The Library	36
List of Members	37
Officers, 1911-12	41
Price List of back parts of Transactions	41
Terms of Membership, etc.	*Inside of back of cover.*

ANNUAL REPORT,

1910-11.

YOUR Council has again the pleasure of reporting that the work of the Association has been carried on with unabated success. The membership is well maintained, and the meetings have been well attended. It is worthy of special note that all the papers read have been by our own members, and that they have, in practically every case, been the record of their own observations or original research. Many of these papers have given rise to profitable discussions, and no doubt they will have a good influence in stimulating others to take a more active interest in the various problems of Geology which await solution. The financial position is quite satisfactory.

MEETINGS.—Eight Evening Meetings have been held, as follows :—

1910.

Oct. 21—Opening Meeting of the Session.

PRESIDENT'S ADDRESS : "A Visit to Vesuvius."

EXHIBITS—the latest maps of the English, and other Geological Surveys ; a new binocular microscope, specially adapted for examining the constituent parts of rock specimens, without slicing ; ejectamenta from recent eruptions of Vesuvius. THE STAFF OF THE GEOLOGICAL DEPARTMENT OF THE UNIVERSITY. Various minerals, lavas, etc., from Vesuvius. THE PRESIDENT. Minerals and rocks from Paraguay. ERNEST PARSONS, B.Sc. Fossils and rocks from the north-east of Ireland, mollusca from the raised beach, Larne Lough. G. V. WILSON, B.Sc.

Nov. 18—"Notes on an Excursion in Northern Sweden, with special reference to the Iron Ore Deposits of Lapland" (*illustrated by lantern slides, maps, diagrams, and a large collection of specimens, including microscope slides*). STANLEY NETTLETON.

Exhibition of a collection of fossil plants from the Middle Coal Measures of Shipley, Derbyshire, collected by Dr. Moysey, and described by E. A. Newell Arber, M.A., in Proc. Yorks. Geol. Society, vol. 17. part 2.

Dec. 16—" Glacial Geology—Old and New." PROFESSOR P. F. KENDALL, M.Sc., F.G.S.

1911.

Jan. 20—" The Formation of Cavities in the Magnesian Limestone " (*Illustrated by specimens and diagrams*).—ERNEST GUY, B.Sc.

Exhibition of a collection of new lantern slides, illustrating geological and physical features in Cleveland, Upper Wensleydale, the Ingleton and Settle Districts, the coast from Filey to Flamborough, and the Durham coast. GODFREY BINGLEY.

Feb. 17—" The Cleveland Dyke " (*Illustrated by lantern slides, diagrams, and specimens*). WM. N. KING, B.Sc.

Mar. 17—" Alluvial Deposits at Woodlesford " (*Illustrated by lantern slides, maps, diagrams, and specimens*). A. GILLIGAN, B.Sc., and E. L. HUMMEL, B.Sc.

Exhibition of fish remains, and mollusca, from the Norwich Crag, Southwold. THE PRESIDENT.

April 7—" The Lithology of the Millstone Grits " (*Illustrated by lantern slides and specimens*). G. F. PICKERING.

May 12—Annual Meeting. Adoption of Annual Report and Balance Sheet. Election of Officers.

" The Geology of Northern Venezuela." ERNEST PARSONS, B.Sc., F.G.S.

Exhibition of specimens of Cryolite, from Greenland, and Lithium minerals from California, with notes on their occurrence. STANLEY NETTLETON.

Fossils from the Coralline Oolite at Ayton. E. HAWKESWORTH.

The average attendance at these meetings was about 30.

SPECIAL MEETINGS.—On November 15th, 1910, a large number of our members attended a lecture by Dr. Vaughan Cornish, on " The Panama Canal and its Makers," before the Leeds Philosophical and Literary Society, by invitation of its President (Rev. J. R. Wynne-Edwards, M.A.)

On October 11th, Dr. Tempest Anderson lectured before the Leeds Photographic Society on " Matavanu—a new volcano in German Samoa," and many of our members accepted the in-

vitation of the President and members of that society to attend. Again on March 21st, by invitation of the same society, our Association was numerously represented at a lecture by Mr. J. J. Burton, F.G.S., on "Some of the Causes which have produced Beautiful Natural Scenery."

It is very gratifying to receive these invitations from kindred societies, which are much appreciated.

EXCURSIONS.—Apart from those of the Yorkshire Naturalists' Union, which very few of our members attend, there have been five excursions, as follows :—

1910.

June 10—(Evening) Ardsley Ironworks, for the examination of various iron ores.

June 18—Brimham Rocks (jointly with the Leeds Naturalists' Club). Leader : E. HAWKESWORTH.

June 28—(Evening) Ilkley. Leader : J. E. WILSON.

July 16—Clapham. Leader : E. HAWKESWORTH.

1911.

May 10—(Evening) Rothwell Haigh. Leaders : A. GILLIGAN, B.Sc., and E. HAWKESWORTH.

With the exception of the one to Clapham, these excursions were well attended.

LIBRARY.—The collection of books, etc., belonging to the Association is constantly being added to by the receipt of the publications of various societies and institutions. Mr. Arnold Lupton continues his kind gift of the Quarterly Journal of the Geological Society, as published. The Director of the Geological Survey has placed the Association on the list of societies to which the Annual Report of Progress is sent.

TRANSACTIONS.—Part 15 was issued to the members in October, 1910. So as to ensure the publication of some of the papers describing original work, read during this session, it has been decided to proceed with part 16, with a view to its issue by the beginning of the next session.

The sale of back parts has only been small.

MEMBERSHIP.—During the session six ordinary members, two country members, and nine associates have joined the Association. Two associates have become members, and one member an associate. Your Council records, with regret, the death of Rev. E. Maule Cole, M.A., F.G.S., who was an Honorary Member since 1886, and who, in years gone by, rendered many services to the Association. Professor G. R. Thompson, B.Sc., F.G.S., has been elected an Honorary Life Member. Thirteen ordinary members, two country members, and five associates have resigned, or gone away, leaving the roll as follows :—8 Honorary Life Members, 83 Ordinary Members, 9 Country Members, 16 Associates, a total of 116, as against 120 at the end of last session. This slight decrease is more apparent than real, as most of the resignations are those of members, useful in their way, who took very little active interest in the work of the Association.

COUNCIL.—There have been four meetings of the Council, with an average attendance of 9.

On Professor G. R. Thompson, B.Sc., F.G.S., leaving the city to take up an appointment as Professor of Mining, and Principal of the South African School of Mines and Technology, in Johannesburg, a resolution was passed conveying to him the congratulations and best wishes of the Association, and, as a slight token of appreciation of the many services he has rendered to its members, electing him as one of its Honorary Life Members.

In conclusion, your Council desires to express the sincere thanks of the Association to those who have read papers, or exhibited specimens, slides, etc., at the meetings ; to the leaders of excursions ; to the Leeds Photographic Society, and the President of the Leeds Philosophical and Literary Society, for invitations to attend lectures ; to Mr. Arnold Lupton, for his gift of the Q.J.G.S., and to other donors to the Library ; to the University authorities for allowing the use of the rooms ; to Mr. W. Denison Roebuck, F.L.S., for auditing the accounts ; and to the staff of the Geological Department of the University, whose unstinted services continue to be of inestimable benefit to our work

CASH ACCOUNT, MAY 1st, 1911.

Receipts.	£	s.	d.	£	s.	d.
Balance from last Session				15	19	1
Arrears of Subscriptions				3	15	0
Subscriptions for 1910–11 :						
78 Members	19	10	0			
6 Country Members	0	15	0			
13 Associates	1	12	6			
				21	17	6
Subscriptions paid in advance ..				0	5	0
Sales of Transactions				0	9	0
Transfer from Dwerryhouse Fund ..				0	14	0
Bank Interest				0	5	11
				£43	5	6

Payments.	£	s.	d.	£	s.	d.
Printing of Syllabus, Notices of Meetings, etc.				4	3	4
Postage of do.				4	2	3
Stationery				1	2	10
Insurance of Books				0	2	0
Gas, etc., for Lantern				0	5	0
Yorkshire Naturalists' Union				1	0	0
University of Leeds				2	2	0
Sundries				0	18	9
Cost of Transactions, part 15 ..				16	4	2
Cash in hand	1	14	0			
Cash in Yorkshire Penny Bank ..	11	11	2			
				13	5	2
				£43	5	6

BALANCE SHEET, MAY 1st, 1911.

Assets.	£	s.	d.	£	s.	d.
Subscriptions unpaid (after deducting doubtful)	3	10	0			
Less paid in advance	0	5	0			
				3	5	0
Cash in Bank	11	11	2			
Cash in hand	1	14	0			
				13	5	2
Books, Stationery, Stock of Transactions, etc.						
				£16	10	2

Liabilities.

NIL.

Examined and found correct, 2nd May, 1911.

W. DENISON ROEBUCK, Hon. Auditor.

THE IRON ORE DEPOSITS OF LAPLAND.

Abstract of paper read by STANLEY NETTLETON, *November 18th*, 1910.

These deposits possess many features in common, but occupy two distinct areas—Kiruna and Gellivare. The former is the more simple in its geological features, and the more important economically. It is situated in a desolate region 870 miles north of Stockholm, 80 miles within the Arctic Circle, and, apart from the periodic visits of Lapps, was quite uninhabited until mining commenced a few years ago. Now Kiruna is an up-to-date town, with a population of over 7,000. The deposits are literally mountains of iron-ore, which lie on an elevated plateau of vast desolate moorlands and moraines. The ore mountains form the central part of the district, and consist of igneous rocks, syenites, and porphyries, the ores lying in the latter in the form of dyke-like masses of magnetite. The Kürunavaara deposit is the largest mass of ore known in the world, extending to a length of over three miles. The mountain ridge itself is about two miles long, consisting exclusively of iron ore, which, having resisted erosion better than he surrounding rocks, forms a prominent feature in the landscape.

The average thickness of the ore, at right angles to the foot and hanging walls, is 80 yards, taken in sections at intervals of 50 yards. The maximum section shows that in one portion of the ridge the horizontal width of the ore is over 200 yards, and its thickness 170 yards. Borings have been made which afford evidence that though there may be incidental decrease of width of the ore with depth, the ore body extends to a great distance from the surface. Boring finished in ore at nearly 1,000 feet below the level of the adjacent lake, or 1,700 feet below the highest part of the mountain.

The Luossavara deposit, which is quite distinct from that of Kürunavaara, has a length of 1,300 yards, and reaches its greatest width of 50 yards at the top of the mountain. In both cases the contact between the ore and the adjacent rocks is very distinct.

pure ore occurring close to syenite and quartz porphyries, without any apparent intermingling. The ore is almost pure magnetite, and is remarkably free from non-metallic constituents, except apatite, which is always present in small quantities.

The magnetite deposits of the Gellivare district occur in rocks of similar character to those of Kiruna, but the geology of the Gellivare area is more complicated, and metamorphism more strongly developed. The amount of iron present in exported ore is about 68 per cent. and when it is necessary to send to surface ore containing less than 60% of metallic iron, this is placed on stock heaps as a reserve to be utilised when the more valuable portions of the deposits approach exhaustion.

The ore is graded according to the amount of phosphorous present, and this may range from 0.013 to 4 or 5 per cent.

Various theories as to the origin of these ore masses were referred to, and much information was given as to the methods of mining, transit, and output

"ON THE FORMATION OF CAVITIES IN THE MAGNESIAN LIMESTONE."

Paper read by ERNEST GUY, B.Sc., *January 20th,* 1911.

The problem of the formation of cavities in the Magnesian Limestone is inextricably bound up with the "riddle of the origin of dolomite," and therefore a brief summary of the work done upon the latter is necessary.

Two theories at present hold the field. The first is that Magnesian Limestone (or dolomite) was formed by secondary action, *i.e.*, by the subsequent molecular replacement of calcium by magnesium; the second that dolomite was directly deposited from the sea—probably by chemical action. The first theory has generally been accepted, and various ways in which such subsequent replacement could have taken place, have been advanced. Most of these methods could only be applied over a very limited area, so do not help much in the explanation of the Magnesian Limestone. But the chief of them is capable of application. It is this :—great beds of calcareous rock either existed or subsided beneath the level of a sea saturated with magnesium salts. Molecular replacement, accompanied by shrinkage, is then supposed to have taken place, leaving dolomite as the product of a chemical mass reaction. The observations of Elie de Beaumont* upon the amount of shrinkage produced in this fashion, and observations upon the porosity of Magnesian Limestone, have been taken as a remarkable confirmation of this view of its origin. But porosity experiments are notoriously untrustworthy.

The other theory is direct deposition. This may take the form of deposition by organic agency (though this will only apply to a limited area), or of deposition by chemical precipitation.

Many attempts have been made to reproduce the exact conditions under which dolomite could be formed. A summary of these efforts will be found in "The Data of Geo-chemistry" under

* Quoted by Geikie in *Text Book of Geology.*

the heading of "Dolomite." None of the methods there given, however, appear to be of general application, but Herr Linck in the "Monatshenichte der Deutschen geologischen Gesellschaft" Mr. 5, 1909, claims to have solved the problem of the manner in which chemical precipitation could take place under normal conditions of temperature and pressure.

The bearing of the method of formation of dolomite upon the formation of cavities will readily be seen. If dolomite was produced by replacement, then the cavities are due to shrinkage of the rock. If not, then some other theory must be submitted. I suggest the removal of gypsum, or some allied substance, from the rock by solution.

Gypsum, which occurs so constantly in the Magnesian Limestone, was probably formed by chemical deposition, or by growth as crystals from a saturated solution. Many other theories have been advanced, but as with the similar theories regarding dolomite, they are only applicable to limited areas and under peculiar conditions. In support of the chemical deposition theory, it may be mentioned that in one or two sections of rock containing gypsum, this substance was found diffused throughout the dolomite, and thus apparently produced in a similar fashion. Also it is sometimes found as a crystalline deposit filling the interstices between the oolitic grains of certain dolomitic rocks. If the oolitic structure is primary, as Sorby* apparently believed, this strengthens the view of direct deposition. Gypsum usually occurs as nodules varying considerably in size; as beds, usually thin, though sometimes reaching a thickness of two or three feet; or as veins running from nodule to nodule, through the rock. In at least one area barytes is found to occur in a manner precisely resembling that of gypsum, although not in such large masses. This barytes was found in the Roundhay and East Keswick outliers; in fairly large quantities, both as nodules and in veins, at Rigton; lining cavities, and nearly filling them in an exposure near Bramham. In these cavities it was often associated with rhombs of calcite.

* Q.J.G.S., vol. 35, 1879.

The nodules of gypsum are always crystalline, even if they are not made up of idiomorphic crystals, so probably the gypsum "grew" from a saturated solution. The nodules, growing in this fashion, might be expected to possess a smooth under-side, and this was found to be the case with nodules which were extracted by acid from the dolomite. These nodules and veins are best developed in rocks that have not been exposed to atmospheric agencies, and which may be considered to have stood above the permanent water level. In rocks which have been exposed to the action of water a cavernous or honeycombed structure is developed, and gypsum is almost absent, though often shown in microscopic sections. These facts suggest the conclusion that the numerous cavities in the Magnesian Limestone are due to the solution of the gypsum.

This conclusion rests upon the following observed facts.—1. Where Magnesian Limestone is exposed at the surface, gypsum is absent and cavities are generally found. This is true of all the places seen. At Hampole a specimen of the surface rock showed signs of gypsum under the microscope, but this rock is probably upon the same horizon as that encountered at Bentley in the sinking of the pit shaft. Here great quantities of gypsum were obtained, and few or no cavities, except such as were half filled with gypsum. From the quarry at Fryston small quantities of gypsum and selenite were obtained. But about two miles from Monk Fryston is the one apparent exception to the rule just laid down. At Hillam, gypsum is quarried near the surface, and, indeed, at some places actually rises to the surface. In the present workings there is about 12 ft. of red clay, of distinctly Triassic appearance, then 3 or 4 ft. of the material dug for gypsum (containing 92% of Calcium sulphate), and below this 18 ft. of blue grey shale resting on solid rock. This rock, Magnesian Limestone, is not exposed, but a boulder of it which had been dug up contained great quantities of gypsum. Probably then, the Hillam deposits are of Triassic age, and certainly they have been protected by a tough impervious Triassic clay. Consequently the presence of a little

gypsum in the exposed upper beds at Monk Fryston is not significant, except of the amount removed by solution.

2.—Where rocks may be assumed to have lain beneath the permanent water level, they show a cavernous structure, and do not yield gypsum. Thus, in the Barlow boring, the lower Magnesian Limestone was called " honeycomb " rock by the workmen, on account of its structure. But yet it presented a striking parallel with the upper beds traversed by gypsum veins and full of gypsum nodules. Had the holes been filled with this material, the outward appearance would have been identical. But at the base of the Magnesian Limestone here, come black, clayey, deep water marls which are quite impervious. It was from the rock resting on these that the first water encountered came, the quantity being so great that it ran as a constant stream from the bore hole. After the week-end rest, the water was clear, and a sample taken then was completely saturated with common salt and gypsum ; surely a very significant fact. This gypsum must have been removed from the rock in the manner postulated for the production of the cavities.

3.—Where rocks have been protected from the influence of water, gypsum is present, and cavities are absent, or nearly so. Thus in the beds at Barlow, which have been protected above by Triassic marls, and have stood above the permanent water level, great quantities of gypsum are found, besides anhydrite. This is equally true at Bentley, Hillam, Crosby, and Thorne.

4.—Specimens can be obtained showing gradations from the nodule to the cavity. This gradation is well marked, and points directly to the removal of gypsum—or to the subsequent infilling of the cavity by gypsum, though the latter is scarcely probable.

5.—There has been a great amount of solution from Magnesian Limestone rocks, wherever exposed. This is the most important point. The evidence of such solution is comparatively absent in the case of covered rocks, except where they lie beneath the permanent water level. The proof of such solution depends

chiefly upon the evidence derived from fossil beds, marl bands, the formation of stalactitic masses in the limestone, and upon certain concretionary structures. Fossil beds afford valuable evidence. In many places thin beds of shell-limestone were observed, *e.g.*, between Collingham and Wetherby ; beyond Wetherby ; near Sherburn ; in a quarry on the Selby Road ; between Conisborough and Doncaster. These beds are composed almost entirely of casts of fossils, but in nearly every case the shells have disappeared, and usually the shell itself is represented by a hollow. Consequently the shells must have been removed since the solidification of the rock, and could only have been so removed by solution. When actual shells were obtained, sectioned, and tested, they proved to be made of calcite. It may be mentioned here that in the dark impervious shales found at the base of the Magnesian Limestone in the eastern area, several shells of *Lingula* were found, and no fossil casts. Moreover, after careful searching, microscopic traces of gypsum were found. Consequently, in this impervious rock, where no solution could take place, both gypsum and shells were present. Elsewhere the shells have been removed and only fossil casts left, clear evidence of solution. Since the beds are wide-spread, the solution must also have been wide-spread. Marl bands may also be cited as doubtful evidence of solution. In many places—indeed, in all exposed places—the beds of the Magnesian Limestone are separated by thin partings of marl. These probably represent the insoluble residue of a thick bed of dolomite removed by solution. The residue obtained after dissolving a piece of the limestone in dilute acid bears a striking resemblance to this marl. Proof of solution is well shown by certain stalactitic growths. In the quarry at Rigton, a portion of the rock face, at least six feet square, was covered by such a growth. A thick deposit had formed down some joint or crack, and from this numerous stalactites depended. The material was almost pure calcite, showing the usual stalactitic ring structure. In very many other quarries smaller growths of a similar nature were found, wherever the rock afforded room for them. This is undoubted evidence of solution, though, of course, it only applies to such accessible

places as joints and cracks. In addition, there are frequently to be found on the under side of beds, tiny concretions of ferruginous sandy material. These knobs vary in size from that of a pin head to nearly half an inch in diameter, and are almost certainly formed by solution from the bed above.

6.—A doubtful proof of the truth of the theory was afforded by some porosity experiments. First a piece of limestone containing small nodules of gypsum was weighed, and dissolved in dilute hydrochloric acid, and the amount of residue found. Then a piece of honeycomb rock was soaked with wax, dissolved, and weight of residue found. The volume of wax left was then found, and compared with the volume of gypsum. The results did show some ground of comparison, but the experiments cannot be made absolute, and like all porosity experiments only give doubtful results.

From the facts thus briefly stated, the conclusion follows, that very often the cavities in Magnesian Limestone have been produced by the removal of gypsum by solution.

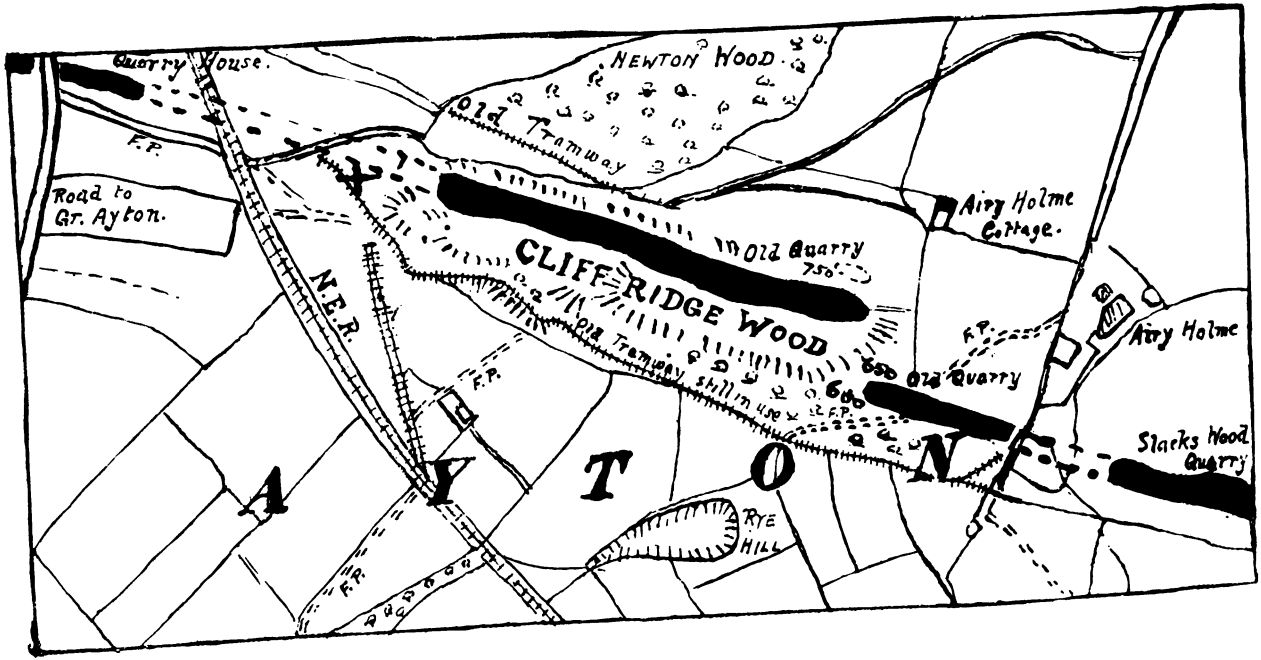
"THE CLEVELAND DYKE."

Paper read by W. NORMAN KING, M.Sc., *February 17th,* 1911.

The main object of the observations here recorded was a comparison of the metamorphism of rocks adjacent to the Cleveland Dyke with that of rocks in contact with the great Whin Sill. In the field, however, certain new features presented themselves, which will be dealt with before the discussion of the metamorphism.

Introduction.—The Cleveland Dyke is an example of what Sir A. Geikie has termed the "Solitary" type. It extends from Fylingdales Moor (Blea Hill Rigg) across Yorkshire and Durham, to Armathwaite and Renwick on the western side of the Pennines. It is also supposed that a continuation of the dyke exists across the Solway near the mouth of the river Nith. The dyke rock is a porphyritic dolerite with large phenocrysts of labradorite which give the rock its peculiar appearance in the hand-specimens, and make its identification so easy. It differs from the Whin Sill in composition, appearance and specific gravity. It is probably of Tertiary date, thus more recent than the Whin Sill.

Easterly Extension.—With regard to the easterly extension of the Cleveland Dyke, I have made careful search for further evidence of its extension to the east of the outcrop marked by the Geological Survey. Both Hollin Gill and Jugger How Beck were carefully searched for further evidence as to the extension of the dyke but only two pieces of the rock were found, the occurrence of which I regard as fortuitous, the pebbles probably having fallen into the watercourse from some road or path. All the stream courses in the neighbourhood of Hollin Gill and Jugger Howe were searched. This was done carefully because it had been alleged that an outcrop of the dyke had been found near Hayburn Wyke. A footnote in the G.S. Memoir (Jurassic Rocks of Britain, Yorks. vol. 1.) throws a little light on this statement. "A portion of these beds [the calcareous beds of the Grey Limestone series of Spindle Thorn on Spaunton Moor] which crops out on the coast at Hundale Point near Cloughton, has been mistaken for whinstone,



DISCONTINUITY OF OUTCROP AT GT. AYTON (MAP A.)

and this is no doubt the reason why in so many of the older geological maps the outcrop of the basaltic dyke is represented as continuing through to the coast."

The most easterly outcrop from which specimens of the dyke rock were obtained, was in the smaller of two grub-holes, a little east of the termination of the dyke as mapped by the late Mr Fox-Strangways.

If therefore the dyke extends further east, the surface must fall sharply eastwards, as, if the difference in level were not great, the dyke would be found outcropping in Hollin Gill or the adjacent watercourses ; or crossing the deep gorge through which the Jugger Howe Beck flows. The rock was amygdaloidal at this point.

Vertical Extension.—At Bolam, Dr. Teall recorded a case of the thinning of the dyke, At Great Ayton, although the dyke does not die out before reaching the surface, in open section, a similar phenomenon takes place, for in the lower drifts of Messrs. Winns workings I obtained a measurement across the dyke of 91 feet, while in a disused working higher up on Cliff Ridge, the width was only 20ft. Similar variations were found near Bolam, and at Wood End and Kildale.

There are also displacements in the outcrop at Great Ayton, and where the dyke crosses the Tees. The outcrop is displaced for many yards on Cliff Ridge at Great Ayton. Although the hillside is much encumbered with rubbish from the quarry at the summit of the ridge, it is clear that the outcrops are not continuous, since the quarries stop abruptly at each place. The map accompanying the text will make this clearer, being a reduction of the 6in. map, with the geological features put in during the field-work.

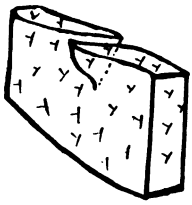
The dyke comes suddenly to a blunt end at the southern outcrop, which is also the lower outcrop on Cliff Ridge, and further up the hillside at an estimated horizontal distance of 50 yards, the next outcrop is found, dying out in a blunt end as shown in the map.

That this is a case in which the surface outcrops are discontinu ous but where the dyke is continuous underground was proved by a visit to the Cliff Rigg Mines, where the dyke was being excavated at lower levels, but almost immediately beneath the discontinuous outcrops. In the lower drifts of the mine, the following features were observed :—The miners were engaged in clearing away the "white back" *i.e.*, the baked Lias shale, and in the furthest working face a section was obtained where the edges of the dyke haded towards each other. Now at Gribdale Gate and elsewhere, the edges of the dyke are parallel, thus giving the dyke a sharp southerly dip. This fact, together with the one recorded above, also that the working face is about ½ a mile from the entrance of the working X, points to the conclusion that though the dyke is discontinuous in outcrop, yet it is continuous underground—the interpretation of the three sections being that the dyke is in the form shown in the sketch.

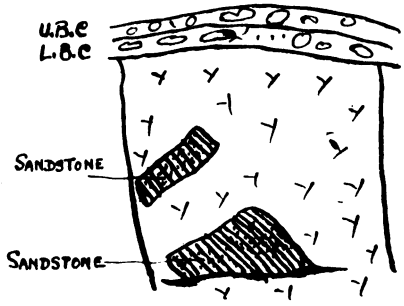
Lateral shifts also occur at Nunthorpe, and Preston, where the dyke is shifted at right angles to its usual direction.

Whilst proceeding along the dyke in a westerly direction, the section shown in the diagram (fig. 3) was seen. It is clear that the dyke has become at this point a small surface flow. The section occurs in the Sil Howe Quarries, a little west of the point where the dyke is crossed by the road from Goathland to Sleights. The dyke rock is found overlying the Estuarine sandstones and shales, and the suggested explanation is that the magma found some weakness in the sedimentary rocks, through which it found its way and flowed out at the surface. The junction of the andesite with the Estuarine rocks is marked by a band of light yellow clay, much weathered ; this being probably the decomposed tachylitic selvedge of the dyke. Throughout the whole area occupied by the Jurassic rocks, this yellow clay band was found, and great difficulty was experienced in obtaining junction specimens in consequence, the Liassic rocks apparently being less susceptible to this kind of change than those of the Estuarine series, either from chemical composition or inferior porosity. This side of the

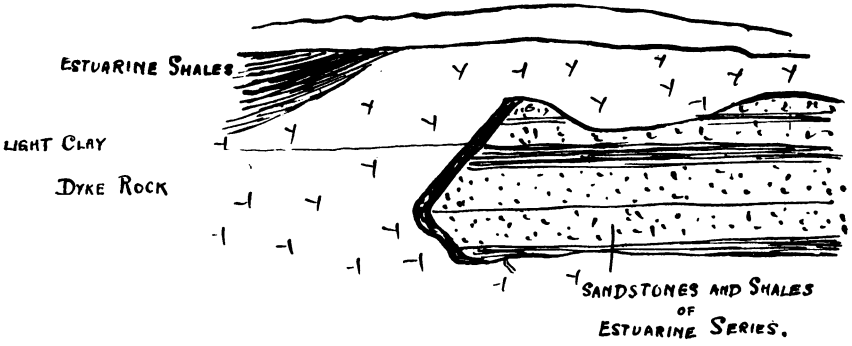
FIELD RELATIONS OF GREAT CLEVELAND DYKE.



DISCONTINUITY AT GT. AYTON
(SEE MAP A.)



SECTION AT EAGLESCLIFFE.



SURFACE FLOW AT SIL HOWE QUARRIES, GOATHLAND.

variable. For example, in the outcrops on Sneaton High Moor, where the dyke cuts through the Estuarines, I found the sandstones and shales altered for a distance of at least 7 feet, but at several points further along the outcrop, the Estuarines were only altered for a distance of 2 feet from the dyke.

In the Lias the same variation was found. At Egton Bridge the Lias shales are altered for a distance of about 12 feet, but at the outcrops in the Lias shales of North Cleveland, the zone of metamorphism hardly reached a width of 3 feet.

Apart from the great variation in width of the dyke itself, *e.g.*, at Kildale the dyke is only 20ft. wide while at Ayton it is 30 yds. in the lower outcrops, there is another cause for this inconstancy in the width of the metamorphic zone. At Wood End railway bridge (amygdules), at Eaglescliffe (xenoliths), as at several other smaller outcrops, there is evidence of horizontal flow, and the dyke probably reached the surface in these places before others, and by widening the fissure on either side, it flowed horizontally thus assisting the magma yet below, to rise to the surface. Thus there would be a constant flow of hot magma past these places whereas at points which the magma reached later, there would be very little or no flow of hot magma. At these latter points there will naturally be less metamorphism of the adjacent rock.

The Estuarine rocks are not so much altered as the Lias rocks, but this is probably deceptive, in view of the different colours, the Lias being altered from black to white, while the Estuarine rocks, both normal and altered, are whitish in colour. The ease with which the rocks weather may also be another reason. Between the pervious Estuarine rocks, the Whinstone is much decomposed, this being shown by a band of red ferruginous clay, from 2 to 3 inches in width, between the andesite and the sedimentary strata. The Whinstone itself is much weathered, more in the pervious Estuarine rocks of Oolitic Age than in the impervious Lias shales.

In examining the metamorphism of the sedimentary rocks in which the dyke is intruded, the most striking feature was the small amount of change visible, in the field, and under the microscope. In the Oolites, this was especially the case; the only beds showing the alteration well being the dark coloured bands in the Estuarines, and the carbonaceous Lias shales.

1.—*Shales.* The shales traversed by the dyke were those of the Lias and Estuarine formations. Great difficulty was experienced in obtaining sections which showed gradation towards the dyke, since the quarries are generally along the dyke. A good transverse section was obtained however, at Egton Bridge, and here the different grades of metamorphic effect are well shown. (*Plate* 1, *fig.* 2, *plate* 3, *fig.* 6). Here the Lias forms the country rock, the dark blue shales being baked hard, although fossils are preserved in the contact rock.

Specimens of *Inoceramus dubius* and a small ammonite were found in the altered shale. Outwardly the shale was baked white, and it had also lost some of its fissility, having acquired a somewhat flinty fracture.

Under the microscope, the shale did not show much evidence of alteration in the specimens obtained from the more remote parts of the section, but in the section of rock from about 3 feet away there was definite evidence of recrystallisation. Under the lower power, the rock had a spotted appearance between crossed nicols. The higher power showed that the spots which were light coloured in a dark field, were composed of small sheaf like and fan shaped aggregates of a mineral which was colourless, had a fairly high double refraction, and gave straight extinction. This mineral is apparently new muscovite, which has been developed as an alteration product, since in normal shales, the micaceous material is not in small definite needle-like crystals, as was the case under observation. There is also the definite "criss-cross" structure, which Hutchings maintains must be secondary, for in normal shales the crystals all lie oriented in one plane, whereas in fig. 6

they lie oriented in all directions. This is the only definite evidence of a development of new minerals in the contacts of the Cleveland Dyke, the other slides being very disappointing, being to the eye much altered, yet showing very little sign of alteration in composition or in structure under the microscope.

In the sandy shales of the Estuarine series the sandy matter is recrystallised to a quartzite while the argillaceous matter shows signs of a development of new minerals, which however, could not be definitely determined with the higher powers, even with oil immersion.

An interesting development of the metamorphism of the Lias shales was found in the centre of the working face of the northern drift in the mines of Messrs. Winn, of Great Ayton. Here I found large irregular shaped cavities varying in size up to four inches in diameter. These cavities contained, in many cases, crystals of quartz and the dog-tooth variety of calcite, and in every case seen by the writer the crystals were covered with a dark oily liquid which had evidently filled the cavities. As the pores are broken up, this oily liquid oozes out and covers the working face, and an instance was on record where about half a pint of a yellow oily liquid was obtained from a geode in the centre of a large block of the Whinstone. Unfortunately this had not been preserved. This liquid, I suggest, is a distillation product of the Lias shales which the dyke traverses at this point. This was especially interesting, since close by, near Gribdale Gate, there is a thick layer of carbonaceous material which is probably the fixed product of the distillation.

2.—*Sandstones.* The sandstones of the Estuarine series show the effect of alteration remarkably well and become close-grained quartzites, with more or less interstitial matter (Specimens 25, 26, 27). Sometimes a gradation is obtainable, the quartz mosaic becoming more definite and the cementing material less and less in amount as the specimens are taken from rock nearer to the junction. To the naked eye, it appeared as though the magma

FIG 1.

Typical section of Dyke Rock, Fylingdales Moor. × *20.*

Phenocrysts of felspar (labradorite) in a microcrystalline groundmass of felspar (labradorite) and anorthite and specks of magnetite.

FIG. 2.

Junction Specimen, Egton Bridge. × *20.*

The dyke rock with phenocrysts of labradorite is shown,—the groundmass in marginal sections being glossy, and containing crystals and microlites of felspar. The line of junction is marked by a narrow band of red oxide of iron, probably due to weathering. The metamorphism of the shale in this slide is very slight, the rock in the hand-specimen being baked white, and hardened, but no new structure in minerals could be seen.

(Photographed by A. Gilligan).

FIG. 3.

Contact Rock, from Cock Lake Sike, Sneaton Moor. × 20.

The unaltered rock is an Estuarine sandstone, and has been re-crystallised, as shown in the section, no individual crystals of quartz being present. Cooling has taken place from various directions, and a rude spherulitic structure has been developed, and is shown by the two "black cross figures."

FIG. 4.

Section of sandstone, 3 feet from the junction, Cock Lake Sike (same exposure as fig 3). × 20.

Here the metamorphism has not been so severe, though there has been re-crystallisation, with the formation of a close mosaic of quartz, and a complete destruction of the interstitial matter of the normal rock.

(Photographed by A. Gilligan).

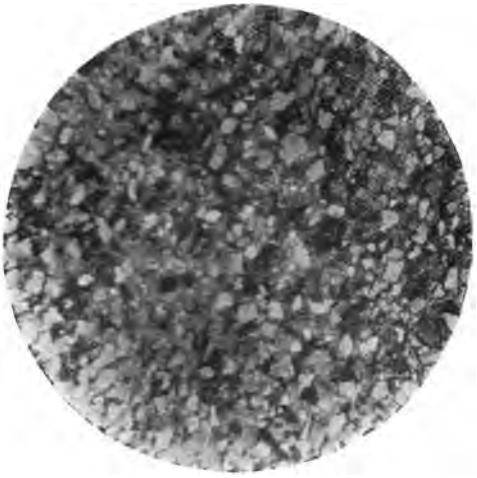


FIG. 5.

Section of Estuarine sandstone, 7 feet from junction, same locality and horizon as fig 4. × 20.

Here the rock is practically normal, consisting of grains of quartz in a groundmass of iron-oxide, quartz, and a little calcite. The grains of quartz are smaller than in fig 4.

FIG. 6

Lias Shale, 3 feet from edge of dyke, at Egton Bridge. × 140.

Here the shale has undergone re-crystallisation In the hand-specimen the rock was baked white, and hardened. In the slide the lighter specks are fans and sheaves of secondary mica (muscovite), which are oriented with the long axes across the bedding, clearly being new formations due to metamorphism. One or two of these can be seen in the N., and S.W quadrants.

(Photographed by A. Gilligan).

had been injected along the bedding planes, but microscopic examination proved the material so found to be iron pyrites. The quartz in other sections was recrystallised into an interlocking mosaic, the original crystals being indeterminable in some cases, but in others their shapes could still be seen. The structure of the rock in fig. 3 is very peculiar. These appear to be large spherulites of quartz which give uniaxial figures in convergent light. On applying the quartz plate which gives the violet of the second order, the figure gave blues in the N.E. and S.W. quadrants. The mineral is therefore positive. The spherulites appear therefore to be of quartz, the scaly and spherulitic structure being due to the escape of steam from the hot rock at the time of extrusion. Calcite is also developed in the slide, probably being a recrystallisation product of the matrix. Chlorite is also present.

Specimen 8 is another quartzite, and is composed of a colourless mineral with lines of black round the crystals. Between crossed nicols it is found that this is an interlocking mosaic of quartz and a little felspar. The grains interlock with one another, and far less matrix is present than is the case in specimen 5, taken from the same outcrop, but more remote from the junction.

REFERENCES:

Tate and Blake—"The Yorkshire Lias."

Dr. Teall—Q.J.G.S., vol. 40.

W. M. Hutchings—Geol. Mag. 1894.

Geol. Survey Memoir—Jurassic Rocks of Britain—Yorkshire, vol. 1.

ALLUVIAL DEPOSITS AT WOODLESFORD.

Abstract of paper read by A. GILLIGAN, B.SC., AND E. L. HUMMEL, B.SC., *March 17th*, 1911.

The deposits described were opened out during the making of the new Water Haigh Collieries, of Messrs. Henry Briggs, Son, & Co., Ltd., in the neighbourhood of Woodlesford. The area covered by the alluvium is about two and a half square miles, and the 50 ft. contour almost exactly defines the boundary on the river side. It is marked on the Geological Survey map as the "second river terrace," and its terrace-like appearance is very striking indeed, so much so that when the question of the exact site for the collieries had to be fixed, Mr. Hodges, manager to the company, saw that the terrace would afford excellent facilities for dealing with the loading of the coal, sidings, etc. During the shaft-sinking operations much difficulty was experienced with a bed of running sand, and the large amount of water which found its way to the shafts, which had of course to be pumped out.

DESCRIPTION OF THE DEPOSITS.

It is not proposed to go into detail for each different bed of sand, gravel, or clay, but to treat them generally. The section given shows the succession of beds in the cuttings made to the N.W. of the shafts.

	ft.	ins.
Top soil and poor clay with pebbles	3	0
Finely laminated clay	2	0
Gravel with large pebbles ..		6
Fine yellow sand, current bedded	2	0
Gravel (coarse)	1	6
Fine clayey sand	1	0
Banded sand (clay and loam bands)	2	6

SANDS.—The thickness of the beds was very variable, and the current-bedding very pronounced, the general direction indicating deposition by water flowing E.S.E. When examined

microscopically, the sands were found to consist of quartz, felspar, grit fragments, mica, ironstone grains in great abundance, coal, and Coal-Measure sandstones and shales, all being coloured with the oxides of iron and manganese.

Very few garnets or zircons were found.

One very noticeable feature was the development of new crystal faces on the quartz, exactly similar to the quartz grains in the Millstone Grit, and indeed showing that they had been derived from that rock, and not undergone much attrition.

GRAVELS.—The pebbles were very variable in size, the largest being about 6ins. × 3ins. × 2ins., mixed with sand of extreme fineness. They were somewhat irregularly laid, but there was a general tendency for them to lie N.W. and S.E. Ironstone nodules of a flattened type were very common.

The gravel which underlay the laminated clay (see section), effervesced briskly in dilute hydrochloric acid, chiefly due to small fragments of limestone and calcite present. Small pieces of grit and Coal Measure sandstone effervesced slightly, and seemed to be impregnated with calcite.

CLAYS.—There were two beds of clay separated by a varying thickness of sand and gravel. Whilst the base of the top bed of clay maintained a constant horizon, the top of the lower bed of clay, which was exposed in the eastern end of the cutting, was undulating, and the sand and gravel gained in thickness where the lower bed of clay was thinner. This would point to denudation of this clay by a stream which shifted its course.

The laminated character of the clays was very striking,—the alternating layers being light and dark brown in colour. The number of laminæ to the inch varied from 90 to 130. The dark laminæ were fine grained, with some minute quartz grains which were very angular. The light laminæ were coarser grained, and

contained much more quartz than the dark ones. Another curious feature was that each of the light laminæ effervesced with dilute hydrochloric acid, whilst the dark ones were quite unaffected. The upper part of each bed of clay had its lamination destroyed by penetrating rootlets, and in many cases it was found that the hole made by the rootlet had been infilled with calcite. Concretions of practically pure calcium carbonate, of very irregular shape, were found in large quantities scattered through the clays, reminding one of the "race" in the Thames Valley brick earths, and the septarian nodules of other clayey deposits.

The authors have tested many other laminated clays of undoubted glacial origin, and have found that without exception the light coloured bands all effervesce with dilute hydrochloric acid, showing the presence of calcium carbonate.

No fossils have been discovered in these deposits.

Taking into consideration the whole of the facts, it seems much more probable that these deposits are of deltaic origin, rather than ordinary river terraces, and belong to the period when the North Sea ice blocked the mouth of the Humber and held up a glacier lake in the central valley of Yorkshire (Kendall, Proc. Yorks. Geol. Soc., vol. xv., pt. 1, pp. 38-39).

Oulton Beck has possibly brought down a large part of the material from the large patches of glacial gravel and sand which it has cut through at Rothwell and Oulton, which deposits have been described by Mr. Hawkesworth in Proc. Yorks. Geol. Soc., vol. xv., pt. 3, pp. 456–462. The authors tender their thanks to Mr. Godfrey Bingley for his kindness in photographing the exposures, and making the lantern slides which were shown at the time this paper was presented to the Association, also to Mr. Hawkesworth for his help in the field.

"NOTES ON THE LITHOLOGY OF THE MILLSTONE GRIT, (ROUGH ROCK), OF HORSFORTH, NEAR LEEDS."

Read by G. F. PICKERING, *April 7th,* 1911.

To the ordinary amateur geologist, the Millstone Grit is not particularly inviting, but, being stationed upon it, I was constrained to endeavour to extract some knowledge from it.

The quarry in the Rough Rock from which most of my specimens were obtained, is on Cragg Hill, Horsforth, and about half a mile from the Whitehall Quarries, on Butcher Hill, where the Coal Measures are seen directly overlying the Rough Rock. The quarry shows about 60 feet of Rough Rock, and though the shale which usually separates it from the flags which form the next lower member of the series is not exposed, it cannot be far below, as water always stands on the floor of the quarry. In another quarry, now disused and partly filled up, a short distance to the west, on Cragg Hill, 13 inches of shale was bored through in an unsuccessful attempt to reach the flags, though nearly a mile to the east, the Rough Rock is seen resting upon the flags without any intervening shale.

The Rough Rock is exceedingly variable in texture, its constituent grains ranging from 1.5 inches down to .01 inch, so that it may be said to vary from a conglomeratic grit to a fairly fine sandstone. It consists chiefly of quartz, with some felspar and mica, the cementing materal being usually argillaceous. Under the microscope, plagioclase may also be seen.

QUARTZ PEBBLES.

Rubbed-down sections of these, examined with polarised light, show that their constituent particles have a decidedly drawn-out appearance, which was pointed out by Dr. Sorby as being characteristic of the quartz from gneiss and mica-schist ; and they all show undulose extinction, which is further proof of this. Some of these quartz sections show many bubbles, but these do not appear to contain any gaseous cavities, nor have I seen any cubical crystals in them.

Felspar Pebbles.

Sections of at least 20 of these have been made, and every one was found to be microcline. Spectroscopic examination failed to reveal either lithium, calcium, or potassium, proving that they were soda-microcline. The specific gravity of three fair-sized pieces was 2.61, 2.60, and 2.54, which are higher than that of the Rough Rock from which they were obtained, suggesting that the material must have been laid down by a rapid current, without the grains having afterwards been sorted by water.

Other Constituents.

A few pegmatites were found, in which the felspar was also microcline. Two fragments of a granitic rock were found, both containing orthoclase and plagioclase. Their most characteristic feature is the absence of ferro-magnesian minerals, so they must be described as aplite. The quartz in both shows undulose extinction, and the specimens show strong evidence of crushing.

Pebbles of black chert, also quartzite, were found, besides two very small fragments of crystalline rock, of an amethystine colour.

Scattered throughout the Rough Rock may be seen what I at first took to be small pockets of mud, but on drying, the substance became so hard that it could only be broken with difficulty. One specimen shows one of these pockets associated with pebbles one inch long, which makes it fairly clear that mud could not remain coherent in a current of water strong enough to transport such pebbles, so one is forced to conclude that this material is an actual rock. It gives no effervescence with H.Cl. and one of its most noticeable features is the large quantity of mica it contains. Some of it has been ground and levigated, and awaits further examination.

Sand Grains.

The finer sand grains are brownish-yellow in colour, and the iron causing the colour is not nearly so easily removed by acid as is that from the sands at the base of the Permian. It was put

through sieves to separate the .01 to .11 inches from the finer. The grains are mostly quartz, with some felspars, and mica. Under the microscope the former show considerable differences. Some few are quite clear, and show the faces of the crystals, but the majority show the corroded appearances mentioned by Dr. Sorby as found in most quartz grains from decayed granite, and he suggested that this was probably due to the action of alkaline silicates set free by decay of felspar. Having had commercial experience of the difficulty of dissolving quartz in alkalies, I had doubts as to this explanation, so by way of experiment, placed a weighed piece of quartz in a solution of sodium silicate. After being left in this for 14 weeks, then washed, dried, and weighed, it was found to have lost .34% in weight, quite a large amount, considering the short time, proving that Dr Sorby was right as usual. The finer portion of the sand was levigated, to separate the kaolin, and much of the mica. The quartz grains in this portion are very clear, have angular outlines, and do not appear to have been at all worn, as demonstrated by Dr. Sorby, and Phillips.

Specific Gravity.

I have determined the sp. gr. of a few specimens of Millstone Grit, from different localities and horizons, the record of which may be useful in the future.

Rough Rock, Cragg Hill, Horsforth	2.55
Flags below same, Apperley Lane	2.48
Third Grit, Otley Chevin	2.47
Ditto. Harewood	2.40
Ditto. Brimham Rocks	2.36
Kinderscout Grit, Strid, Bolton Woods	2.45

Current Bedding.

Wherever possible, the current bedding of the Rough Rock was measured, and, though the figures may have some value for purposes of reference, they are too few and variable for any definite conclusions to be drawn from them.

Sixteen measurements were taken, giving the following directions :—

1	N.N.E. to E.
3	E.S.E. to S.
9	S.S.W. to W.
3	W.N.W. to N.

Out of these, there were 2 examples showing an angle of 10°, 2 of 15°, 6 of 20°, 2 of 25°, 2 of 30°, and 1 of 40°.

In conclusion, I have to express my sincere thanks to Mr. A. Gilligan, B.Sc., F.G.S., whose advice and assistance have been of great benefit.

REFERENCES :

H. C. Sorby—"On the Structure and Origin of the Millstone Grit in South Yorkshire." Proc. Yorks. Geol. and Polyt. Society, vol. 3., p. 669.

Phillips—Q.J.G.S. No. 145, 1881.

FIG. 1.

Showing places where boulders of Magnesian Limestone were found (marked by sticks).

FIG. 2.

General view, looking west.

(Photographed by F. Ellison).

ROTHWELL HAIGH GRAVEL PIT.

NOTES ON PERMIAN BOULDERS FOUND AT ROTHWELL HAIGH.

E. HAWKESWORTH.

Since the description of the Rothwell Haigh gravel-pit was published in L.G.A. Transactions, part 13, large quantities of material have been extracted, especially from the western face of the section. On a recent visit, along with Mr. A. Gilligan, B.Sc., F.G.S., we were surprised to find a number of boulders of Magnesian Limestone, of different types. Several pieces contained specimens of *Schizodus obscurus* in plenty, and had evidently come from the base of the limestone, as exposed in the neighbourhood of Garforth. Other pieces were of the purer and more crystalline type, almost entirely composed of shell fragments, similar to the limestone found in the lower parts of the quarries in the Micklefield district. A large piece of beautifully crystalline pure dolomite was also found.

All these were obtained from a bed of fine, tough red clay, which also contained many other boulders and pebbles of western origin, such as have been recorded previously in these deposits. At first sight, the bed which is 3 to 4 feet thick, suggested Boulder Clay, but closer examination showed it to be finely laminated in places, which is further evidence of the lacustrine origin of these deposits.

The Magnesian Limestone escarpment is some miles to the east and the north of Rothwell Haigh, and this mingling of western and eastern erratics is worthy of note. The only explanation of the presence of these Permian boulders here seems to be that they have been "rafted" into the lake, and have fallen into the clay during its deposition.

Evidently there is still much to be learnt about these deposits. Just as this volume is being completed for the press, Professor P. F. Kendall informs me that on a recent visit to this section, on its eastern side, he saw typical Boulder Clay, containing, in addition to the western erratics already recorded, many angular boulders of a crystalline Carboniferous Limestone. He also obtained a well-scratched piece of hard sandstone.

REPORTS OF EXCURSIONS.

By E. HAWKESWORTH.

ARDSLEY.—June 10th, 1910 (evening). A visit was paid to the works of the West Yorkshire Iron and Coal Co., Ltd., for the purpose of examining the various ores used there. Work was commenced on the heaps of ironstone from Frodingham, which is obtained from beds of Lower Lias age. Fossils in this were somewhat scarce, and badly preserved, but several characteristic ones were seen, such as *Gryphæa incurva*, and *Pleuromya*. The calcined ironstone from Caythorpe (Middle Lias) yielded large numbers of well preserved fossils—*Terebratula punctata* being particularly fine and abundant. When sufficient fossils had been collected, some little time was spent in examining various manganese ores from India and the Caucasus, and rhodonite from Spain. Besides these, Carboniferous and Magnesian limestones were seen, so those present had an exceptional opportunity for acquainting themselves with a large variety of interesting rocks, from distant places, with very little trouble or expense. The party was afterwards shown over the works, the various processes in the manufacture of pig-iron being lucidly explained by Mr. Thos. Hoskinson, Jun., to whom a hearty vote of thanks was accorded.

BRIMHAM ROCKS.—June 18th, 1910. (Jointly with the Leeds Naturalists' Club and Scientific Association.) Leader, E. HAWKESWORTH.

A large party assembled at Dacre station, and the walk up the hill to the rocks was made quite leisurely. A visit was paid to a small quarry below the plateau on which the rocks stand, to examine the "shell bed" (Cayton Gill series), which yielded a large number of fossils, such as *Productus, Spirifer, and Orthis.*

After doing the round of the rocks, and taking tea, a convenient spot, overlooking the valley of the Nidd, was selected, and an informal meeting was held, over which Mr. J. W. Taylor presided, and the leader gave an address on the physical features

and history of the district. After stating the conditions prevailing at the close of the Silurian period, he said that a sea came into being, not necessarily a very deep one, but consisting of clear water, free from sediments, extremely favourable for the development of various forms of marine animals, especially those having calcareous skeletons or coverings. The boundaries of this sea can be traced. Its deepest part was where Derbyshire now is, and towards the north a great river or rivers ran into it, depositing huge quantities of sand and mud, the result of the wearing down of a land area to the north or north-east. Towards the margins of the sea, these sediments became intercalated with the deposits of the remains of the animals living in the sea, and gradually shallowing conditions prevailed, until the estuaries became swamps, clothed with rank vegetation. This sequence of events was not exactly continuous, there were several oscillations, sometimes the sediments were spread out further than at others, sometimes the marine conditions encroached upon the estuarine ones. The sea is now represented by the great mass of Carboniferous Limestone which in Derbyshire is quite 1,500 feet thick, practically pure limestone, mainly composed of organic remains, chiefly corals, echinoderms, and molluscs. West and north this limestone becomes thinner, and more and more split up by beds of sandstone and shale, or mixtures of these and calcareous matter. From Derbyshire to Northumberland the series of rocks gradually changes, until at Alston Head it is represented by about 1,200 feet, of which only about 300 feet is pure limestone.

The immense deposits of sand and mud became consolidated in course of time, and now form the series of rocks known as the Millstone Grits, which cover a greater area of the West Riding than any other rocks. They consist of thick beds of grit or coarse sandstone, with intercalations of beds of shale. These grits furnish evidence of having been derived from a granitic area, they are mainly made up of fragments of quartz, with some felspar, and a few flakes of mica, the third constituent of granite, but this is much more common in the shales. Pieces of granite

have been found recently in similar grits in West Yorkshire, but careful examination and comparison has so far been unable to identify them with any known outcrop of granite. The grits are of estuarine origin, and in many places contain remains of trees and plants. There were incursions of marine conditions from time to time, the "shell bed," full of marine fossils, proving one of these. The enormous accumulations of vegetable matter during the subsequent prevalence of swamp conditions now form our coal seams.

All these beds of rock, forming the Carboniferous system, were subjected to a series of earth movements, bending them into troughs and folds, or completely severing the beds by faults. This breaking up rendered the surface more amenable to the denuding agencies of the atmosphere—heat, rain, wind, and frost, which have ever since been wearing it down, the rivers carrying the material away, in due time to form new land surfaces.

Brimham Rocks are the weathered escarpment, overlooking Nidderdale, of one of the beds of Millstone Grit. They are all that remains of a bed of grit, the carving out of this wonderful and extensive group of rocks having been effected by atmospheric agencies, and those present saw ample proofs that the process is still going on. Some of the layers are much softer than others, thus, of course, weathering away the more rapidly, leaving the harder layers jutting out above or below. Many illustrations of this were seen, in some cases the removal of the softer bed having caused the overlying harder one to tilt, or completely collapse. In other cases there is great difference in the hardness of parts of the same layers, the softer parts being weathered out, leaving hollows, and, in some, holes through the rocks. In other instances the weathering has worked along the perpendicular master joints of the bed, giving rise to other rock forms. The older geologists taught that these rocks owed their present wonderful and fantastic forms to the action of the waves of a sea, but, as such a sea would necessarily extend over a very large area, and there are no signs of its presence elsewhere, it is an untenable theory.

As showing the effects of the folding and faulting before mentioned, it was pointed out that whilst the Brimham plateau was Millstone Grit ; Greenhow Hill, some hundreds of feet higher, was Carboniferous Limestone, though this in the ordinary sequence was hundreds of feet below the grit ; and at Ripley, in the valley bottom, there was a patch of Magnesian Limestone, which is on a much higher horizon than the grit. The glacial history of the valley was mentioned, and allusion was made to its early inhabitants.

ILKLEY.—June 28th, 1910 (evening). Leader, J. E. WILSON. A large party walked over Rombald's Moor, by way of the Cow and Calf Rocks, to Lanshaw Delves, to examine the lateral moraine of the Wharfedale glacier. Pebbles of chert were found on the moor above the moraine, and nearer Airedale.

CLAPHAM.—July 16th, 1910. Leader, E. HAWKESWORTH. The route followed was the same as that of the Y.N.U. excursion, in 1908, which is described in L.G.A. Transactions, part 15, page 41.

ROTHWELL HAIGH.—May 10th, 1911 (evening). Leaders—A. GILLIGAN, B.Sc., F.G.S., and E. HAWKESWORTH. The object of this excursion was to examine new sections in the gravel pit at Rothwell Haigh. These deposits are described in L.G.A. Transactions, part 13, and more recent observations are recorded in the present part.

THE LIBRARY.

The Books belonging to the Association are in the care of the Hon. Secretary, who is always glad to arrange for the loan of them to members, on suitable notice being given, and postage, etc., paid.

Besides a number of miscellaneous pamphlets, etc., and a few books, such as Tate and Blake's "Yorkshire Lias"; Lyell's "Principles of Geology"; Phillips' "Yorkshire Coast"; Mantell's "Pictorial Atlas of Fossils"; the following are received as published:—

"The Naturalist" (monthly).
"The Quarterly Journal of the Geological Society of London."
"The Proceedings of the Geologists' Association" (London).
"The Proceedings of the Yorkshire Geological Society."
"The Transactions of the Yorkshire Naturalists' Union."
"The Transactions of the Liverpool Geological Society."
"The Transactions of the Leeds Naturalists' Club."
"The Transactions of the Leeds Astronomical Society."
"The Transactions of the Manchester Geological Society."
"The Transactions of the Hull Geological Society."
"The Transactions of the Edinburgh Geological Society."
"The Annual Report of Progress of the Geological Survey."
"Journal of the Manchester Geographical Society."
"Memoirs of the Manchester Literary and Philosophical Society."
"British Association Reports."
"Records of the Australian Museum."
"United States Geological Survey—Bulletins, Professional Papers, and Monographs."
"Reports of the Smithsonian Institution."

List of Members at end of Session, 1910-11.

Those who have contributed Papers or conducted Excursions are distinguished by an asterisk.*

Year of Election.

Honorary Members.

1886 *Horne Wm. F.G.S. Leyburn.
1891 *Marr J. E. D.Sc. F.R.S. F.G.S. Cambridge.
1874 *Miall Prof. L. C. F.R.S. F.G.S. F.L.S. Letchworth.
1887 *Sollas, Prof. W. J., M.A., D.Sc., LL.D., F.R.S., F.G.S., Oxford.
1890 *Woodward, A. Smith, LL.D., F.R.S., F.L.S., F.G.S., British Museum, (Natural History), London.
1896 *Groom, Prof. T. T., M.A., D.Sc., The University, Birmingham.
1907 *Bond, J. W., Torre Road, Burmantofts, Leeds.
1902 *Thompson, Professor G. R., B.Sc., F.G.S., School of Mines, Johannesburg, South Africa.

Ordinary Members.

1904 Abbott, A., 2, Langdale Terrace, Headingley, Leeds.
1907 Andrews, W. A., M.Sc., 11, Roundhay Place, Leeds.
1891 *Bailey, J. W., 2, St. Mark's Villas, Leeds.
1897 Bain, J., The Larches, Rutland Road, Harrogate.
1910 Baldwin, H., A.R.C.Sc., 3, Winstanley Terrace, Leeds.
1904 Beahan, J. J., City Engineer's Office, Leeds.
1882 *Bedford, J. E., F.G.S., "Arncliffe," Shire Oak Road, Leeds. (*Past President*).
1889 *Bingley, Godfrey, "Thorniehurst," Shaw Lane, Leeds (*Past President*) (*Member of Council*).
1895 *Bees, W. J., B.Sc., 43, Ash Grove, Leeds.
1908 Booth, Peter, 232, Park Crescent, Frizinghall, Bradford.
1911 Bottomley, E. W., 12, Bellbrook Avenue, Harehills, Leeds.
1909 Bowen, David, Mining Dept., The University, Leeds.
1883 *Branson, F. W., F.I.C., 14, Commercial Street, Leeds (*Vice-President*)
1908 Branson, F. H., Wynneholme, Far Headingley, Leeds.
1909 Broadbent, F. J., Croft House, Mirfield.
1904 *Burnet, Arthur, 52, Prospect Terrace, Hunslet, Leeds (*Member of Council*).
1908 Burgess, W. E., B.Sc., 17, Pawson Street, Morley.
1910 Champion, C. L., B.Sc., 31, Virginia Road, Leeds.
1906 *Cheetham, C. A., Nutting Grove, Farnley, Leeds.
1905 Charlesworth, A., M.Sc., 100, Bankside Street, Roundhay Road, Leeds (*Member of Council*).

1891 *Clough, S., Micklefield.
1906 *Crowther, Hy., F.R.M.S., The Museum, Leeds.
1890 *Cuttriss, S. W., M.I.E.E., Richmond Mount, Leeds.
1908 Dixon, Wm., City Engineer's Office, Leeds.
1896 Dodgson, Aquila, South Lea, Kirkstall Lane, Leeds.
1907 Duchesne, H., B.Sc., Ashdown, Saffron Walden.
1896 *Dwerryhouse, A. R., D.Sc., F.G.S., Deraness, Deramore Park, Belfast (*Past President*).
1905 Everett, J. H., B.Sc., 23, Cranbrook Avenue, Beeston Hill, Leeds (*Member of Council*).
1910 Firth, Herbert G., 63, Headingley Mount, Leeds.
1907 Forster, Alex., B.Sc., 11, Savile Place, Chapeltown Road, Leeds.
1891 *Forsyth, David, M.A., D.Sc., 101, Caledonian Road, Leeds (*Past President*) (*Member of Council*).
1907 Foster, Hy., 48, Ridge Mount, Armley, Leeds.
1909 Gill, E., Fold Head, Mirfield.
1907 *Gilligan, A., B.Sc., F.G.S., "Craig Holme," Outwood Lane, Horsforth, Leeds (*Member of Council*).
1907 Grant, C. H., M.Sc., F.R.Met.S., 212, Burley Road, Leeds.
1908 *Guy, Ernest, B.Sc., Beverley Terrace, Dewsbury Road, Leeds.
1893 Hanbury, Chas., 1, Park Place, Leeds.
1907 Hart, Geo. A., City Sewerage Engineer, Leeds.
1886 *Hawkesworth, Edwin, "Sunnyside," Crossgates, Leeds (*Past President*) (*Hon. Secretary*).
1890 Heaton, Hy., "Cot Field," Roundhay, Leeds.
1908 Henzell, Chas. G., City Waterworks Engineer, Leeds.
1910 Hobley, Robt. A., B.Sc., Ashville Terrace, Farnley, Leeds.
1875 *Holgate, Benj., F.G.S., "The Briers," Roundhay, Leeds (*Past President*).
1906 *Hodges, Isaac, F.G.S., Woodlesford, near Leeds.
1905 Hornby, John, St. Jude's School, Hunslet, Leeds.
1907 *Hummel, E. L., B.Sc. The Cottage," North Grange Road, Headingley Leeds.
1886 Kay, Stanley, R., High Mead, Wood Lane, Headingley, Leeds.
1891 *Kendall, Prof. P.F., M.Sc., F.G.S., "Rose Dene," Weetwood, Leeds (*Past President*) (*Member of Council*).
1909 Kendall, Percy, B.Sc., "Rose Dene," Weetwood, Leeds.
1906 Keighley, L., 5, Sefton Terrace, Beeston Hill, Leeds.
1908 *King, Wm. N., M.Sc., 28, Dawson Road, Beeston Hill, Leeds.
1908 Margerison, Saml., Grey Gables, Calverley, Nr. Leeds.
1908 Marsden, Oliver, 7, Regent Terrace, Hyde Park, Leeds.
1910 Milner, J. E., B.Sc., 10, Dorset Avenue, Harehills Lane, Leeds.
1889 Mitchell, F., 9, Upper Fountaine Street, Leeds.
1907 Murray, R., The Manor House, Barwick-in-Elmet, Leeds.

1903 *Nettleton, Stanley, Roundwood, Ossett (*Member of Council*).
1895 *Parsons, W., F.R.G.S., City of Leeds Training College, Kirkstall Road, Leeds (*Member of Council*).
1907 *Parsons, E., B.Sc., F.G.S., 13, Colville Terrace, Leeds.
1909 Parry, Miss Ethel, 5, Marlborough Gardens, Leeds.
1908 *Pickering, G. F., Gauroyd House, Horsforth, Leeds.
1909 Pickles, H., B.A., B.Sc., 5, Brudenell Mount, Leeds.
1874 Pocklington, H., 11, Regent Park Terrace, Leeds.
1909 Poole, Granville, B.Sc., 45, Young Street, Doncaster.
1902 Price, A., B.Sc., 16, Northfield Terrace, Wakefield.
1907 Price, J. W., North Terrace, Crossgates, Leeds.
1908 Reason, Sydney, The Outwood, Horsforth, Leeds.
1881 Roebuck, W. Denison, F.L.S., 259, Hyde Park Road, Leeds.
1887 *Rowley, Walter, F.S.A., F.G.S., Alder Hill, Meanwood Leeds.
1904 Robinson, W. J., 54, Cardigan Lane, Leeds.
1908 Shaw, C. H., Purlwell House, Batley.
1906 Stephenson, H. L., 73, Colwyn Road, Leeds.
1909 Sunderland, W., 2, Hovingham Terrace, Harehills Lane, Leeds.
1906 Thornber, W, Oxford Chambers, Victoria Square, Leeds, (*Member of Council*).
1909 Tickle, Gilbert Y., 56, Thorne Road, Doncaster
1906 Turner, F., 34, Wesley Street, Morley.
1904 Walbank, Wm., " Pickrin Lodge," Halton, Leeds.
1908 Walker, Arthur, 1, Headingley Mount, Kirkstall Lane, Leeds.
1908 Ward Jas., E., Hanover Square, Leeds.
1897 *Whitmell, C. T., M.A., B.Sc., " Invermay," Hyde Park, Leeds, (*President*).
1905 Whitmell, Mrs. C. T., " Invermay," Hyde Park, Leeds.
1906 *Wilson, G. V., B.Sc., " Burnholme," Woodlands, Harrogate.
1909 Wills, Albert E., Denby Villas, Knowle Road, Mirfield.

Country Members.

1883 *Brownridge, Lieut. Colonel Chas., F.G.S., M.I.C.E., 21, Willowbank Road, Birkenhead (*Past President*).
1910 Burton, J. J., F.G.S., Rosecroft, Nunthorpe, Yorks.
1889 *Carter, W. Lower, M.A., F.G.S., " Bolbec," Bushey Grange Road, Watford.
1886 Crowther, J. A., Borough Engineer, Southampton.
1910 Crozel, G., Collonges-sur-Saone, France.
1904 *Edwards, E. J., M.Sc., 19, Deri Road, Roath, Cardiff.
1906 *Johns, Cosmo, M.I.M.E., F.G.S., Burngrove, Pitsmoor Road, Sheffield.
1908 Jukes-Browne, A. J., B.A., F.G.S., Floriston, Torre, Torquay.
1911 Hartshorn, John, Leyburn, Yorks.

1911 Milton, J. H., F.G.S., Harrison House, Crosby, Liverpool.
1889 Wilkinson, Jno. J., Burnside, Skipton.

Associates.

1910 Banks, J. C., 2, Midland Road, Hyde Park, Leeds.
1910 Bull, W., 7, Colville Terrace, Beeston Hill, Leeds.
1909 Chapman, Miss S., B.Sc., Geological Dept., The University, Leeds.
1908 Davison, Miss Irene E., B.Sc., 10, Providence Avenue, Hyde Park, Leeds.
1910 Ellison, F. E., B.Sc., Central High School, Leeds.
1910 Fearnley, L. W. K., B.Sc., 2, Dial Villas, Woodhouse Moor, Leeds.
1910 Gregson, Miss A., B.Sc., 60, Hazlehurst Brow, Daisy Hill, Bradford.
1908 Haigh, Jno. H., B.Sc., 98, Chester Street, Carlinghow, Batley.
1908 Kay, Stanley B., High Mead, Wood Lane, Headingley, Leeds.
1910 Lee, H., B.A., 33, Simpson Grove, Armley, Leeds.
1910 Mawson, H., The University, Leeds.
1908 Nicol, Miss Agnes, The Avenue, Halton, Leeds.
1908 Parr, T. A., 62, Broomhill Terrace, Batley.
1909 Rogers, Miss B. B., 14, Manor Terrace, Headingley, Leeds.
1910 Thompson, H. S., The University, Leeds.
1910 Thornton, H., B.Sc., The University, Leeds.

Thirty-Eighth Session, 1911-12.

Officers:

President: A. GILLIGAN, B.Sc., F.G.S.

Vice-President: C. T. WHITMELL, M.A., B.Sc., F.R.A.S.

Hon. Secretary and Treasurer: E. HAWKESWORTH, Sunnyside, Cross Gates, Leeds.

Members of the Council:—

GODFREY BINGLEY.
F. W. BRANSON, F.I.C., F.C.S.
ARTHUR BURNET.
A. CHARLESWORTH, M.Sc.
C. A. CHEETHAM.
J. H. EVERETT, B.Sc.
D. FORSYTH, M.A., D.Sc.
Professor P. F. KENDALL, M.Sc., F.G.S.
STANLEY NETTLETON.
W. PARSONS. F.R.G.S.
W. THORNBER.

Sale of Back Parts of the Transactions.

The Transactions of the Association contain a store of valuable geological information. Most of the subjects are dealt with at length, and the reports of excursions will be very useful to members visiting the localities described. *Part* 14 *contains a classified index of parts* 1 *to* 14. Parts 1 and 10 are now out of print, and the stock of some of the earlier ones is very limited.

Parts 2 to 15, except part 10, containing over 700 pages—to members and associates, 8/6; to non-members, 12/-; postage 6d. extra.

Separate parts for those desirous of completing their set: 4, 11, 12—6d. each to members and associates; 9d. each to non-members.

3, 5, 6, 7, 8, 9—9d. each to members and associates; 1/- each to non-members.

13—1/- to members and associates; 1/6 to non-members.
14—2/- ,, ,, ,, 2/6 ,, ,, ,,
15—1/6 ,, ,, ,, 2/- ,, ,, ,,

Very few copies of part 2 are left, and will only be supplied with full sets.

POSTAGE EXTRA.

Leeds Geological Association.

THE OBJECT OF THIS ASSOCIATION is to promote the study of Geology by means of field excursions, exhibition of specimens, reading of papers, and discussions.

MEETINGS are held on the **third Friday in each month** (except when otherwise stated), from October to May, in the **Geological Department of the University of Leeds (entrance 22, De Grey Road), at 7.30 p.m.**

EXCURSIONS are made frequently to places of Geological interest.

The Association is affiliated with the **YORKSHIRE NATURALISTS' UNION,** which constitutes each member an Associate of that Union, and as such, entitled to attend all its Meetings and Excursions.

A volume of **TRANSACTIONS** is published occasionally, and issued free to Members and Associates.

TERMS OF MEMBERSHIP.

ORDINARY MEMBERS' Subscription, **5/-** per annum.

COUNTRY MEMBERS (residing 20 miles or more from Leeds), Subscription **2/6** per annum.

ASSOCIATES—Assistant Teachers in the Schools of the City, Students in attendance at Geological Classes, and others as the Council may determine, may become Associates. Subscription **2/6** per annum.

Country Members and Associates receive the Transactions as published, but do not receive separate notification of each Meeting and Excursion.

All Subscriptions are due in advance on JULY 1st in each year.

Members are invited to bring specimens for exhibition at any of the Meetings, or to report any matter of Geological interest which may come within their cognisance.

Members may introduce their friends (ladies and gentlemen) at the Meetings and Excursions.

Members are requested to at once notify the Hon. Secretary of any change of address.

Hon. Secretary and Treasurer—
E. HAWKESWORTH, Sunnyside, Cross Gates, Leeds.

CONTENTS

	PAGE
Annual Report, 1910-11	[illegible]
Balance Sheet, 1910-11	[illegible]
The Iron-ore Deposits of Lapland—Nettleton	[illegible]
The Formation of Cavities in the Magnesian Limestone—Eyre	[illegible]
The Cleveland Dyke—King (*with plates*)	[illegible]
Alluvial Deposits at Woodlesford—Gilligan and Bunney	[illegible]
The Lithology of the Millstone Grits—Pickering	[illegible]
Note on Permian Boulders at Rothwell Haigh—Hawkesworth (*with plate*)	[illegible]
Report of Excursion to Ardsley	[illegible]
" " Brimham Rocks	[illegible]
" " Ilkley	[illegible]
" " Clapham	[illegible]
" " Rothwell Haigh	[illegible]
The Library	[illegible]
List of Members	[illegible]
Officers, 1911-12	[illegible]
Price List of back parts of Transactions	[illegible]
Terms of Membership, etc.	*Inside of back of cover*

Soc. Astron. Soc.
presented by Leeds Geol. Assoc.
Nov 1914
Science Library
QE
1
.L48
v. 4
pt. 17

THE

TRANSACTIONS

OF THE

LEEDS GEOLOGICAL ASSOCIATION

PART XVII.

1911-12

1912-13

Edited by the Honorary Secretary

Price 2/-.

Members may purchase extra copies at 1/6 each, postage extra.

UNIVERSITY OF MICHIGAN LIBRARIES

THE TRANSACTIONS

OF THE

LEEDS

Geological Association.

PART XVII.

1911-12

1912-13

EDITED BY THE HONORARY SECRETARY.

LEEDS;

NUTT & CO., LTD., PRINTERS.

Issued Nov. 12th, 1914.

Science Library

CONTENTS.

	PAGE.
Annual Report, 1911–12	3
Financial Statement, 1911–12	7
Some Petrological Characteristics of Underclays—Miss Chapman ...	8
The Ammonites of the Lias—C. Thompson	16
Evidences of Climatic Changes in Geological Times—Kendall. ...	20
Annual Report, 1912–13	25
Financial Statement, 1912–13	30
Notes on Sections in Robin Hood Quarries (*with* 6 *plates*)— Burnet and Everett	31
Presentation to the Hon. Secretary	36
Report of Excursion to Woodlesford	39
,, ,, Ingleton	40
,, ,, Roundhay Park...	41
,, ,, Robin Hood Quarries	42
,, ,, Knaresborough	42
,, ,, Leeds Steel Works	42
,, ,, Askern	42
,, ,, Roundhay	43
,, ,, Burnsall and district	43
The Library	45
List of Members	46
Officers for 1913–14	50
Price List of back parts of Transactions	50
Terms of Membership, etc.	*Inside of back of cover.*

ANNUAL REPORT,

1911-12.

Presented and adopted at the Annual Meeting, May 17th, 1912.

It is once more the pleasant duty of your Council to report that from every point of view, the session just closing has been an unqualified success. There is a good increase in the membership, the meetings have been well attended, the papers, discussions, and exhibits have been of great interest, and the financial position is eminently satisfactory.

Meetings.—Eight evening meetings have been held, as follows :—

1911.

Oct. 20—Opening Meeting of the 38th Session.

President's Address : "Eutectics."

Exhibits—Rock specimens, and microscopic slides, illustrating the President's Address.

By the Staff of the Geological Department of the University : the latest maps and memoirs of the English, and other geological surveys ; fossil woods from Mexico ; Zircon and Monazite sands.

By Mr. C. T. Whitmell, M.A., B.Sc. : igneous erratic rocks from Robin Hood's Bay.

By Professor P. F. Kendall, M.Sc., F.G.S. : Ammonites from Robin Hood's Bay, scratched boulder from Rothwell Haigh Gravel Pit.

By Mr. G. V. Wilson, B.Sc. : sections of rocks used for the sea-wall, Blackpool.

By Mr. M. Odling, B.A., F.G.S. : Rock sections, micro-photographs, diagrams and photographs of the Oolites (Bathonian) of the Oxford district.

By Mr. E. Hawkesworth : A Collection of shells from the Basement Boulder Clay, Dimlington.

Nov. 17—"The Petrological Characteristics of Underclays." MISS S. E. CHAPMAN, B.Sc.

"The Variation in Forms of Stalactites." MR. STANLEY NETTLETON.

EXHIBITS—Specimens and microscope slides illustrating Miss Chapman's paper.

By MR. NETTLETON: A collection of igneous and other rocks from the Isle of Skye, and N.W. Highlands.

By THE PRESIDENT: A collection of rocks, with microscope slides made from them, from Antarctica.

Dec. 15—"The Ammonites of the Lias." (*illustrated by lantern slides of photographs of type specimens*). MR. C. THOMPSON, B.Sc.

1912.

Jan. 19—"Precious Stones" (*illustrated by a collection*). MR. F. PILKINGTON SARGEANT.

Feb. 16—"Evidences of Climatic Changes in Past Geological Times" (*illustrated by lantern slides, and diagrams*). PROFESSOR P. F. KENDALL, M.Sc., F.G.S.

Mar. 15—"Petroleum—its Occurrence and Origin" (*illustrated by lantern slides, and specimens*). MR. ERNEST PARSONS, M.Sc., F.G.S.

The President exhibited a number of remarkable pebbles of igneous rocks found in the Millstone Grit, near Silsden.

Apr. 19—"Some Recent Advances in Geology." MESSRS. A. GILLIGAN, B.Sc., F.G.S., and E. HAWKESWORTH.

May 17—Annual Meeting. Adoption of Annual Report and Balance Sheet. Election of Officers.

"Notes on the Robin Hood Quarries." MR. ARTHUR BURNET.

Exhibition of Lantern Slides, showing geological features in the Ingleton and Scarborough districts, and glaciers in Norway and Switzerland. MR. GODFREY BINGLEY.

Exhibition of a series of specimens and models relating to "Early Man;" saurian remains; rocks and fossils from the Appleby district. THE PRESIDENT, and MR. M. ODLING, B.A., F.G.S.

Microscope slides of siliceous organisms in flint, chert, etc., exhibited by Mr. Burnet, on behalf of Mr. W. HILL, F.G.S.

The average attendance at these meetings was about 30.

SPECIAL MEETINGS.—On October 31st, a large number of members of the Association attended a lecture by Dr. Tempest Anderson, M.D., D.Sc., F.G.S., on "More About Volcanoes," by invitation of the President and members of the Leeds Photographic Society.

On January 16th, by the kind invitation of the President of the Leeds Philosophical and Literary Society (Mr. C. T. Whitmell, M.A., B.Sc.), a large number of our members were present at a lecture delivered before that society by Professor W. W. Watts, D.Sc., F.R.S., on "Charnwood Forest and its Buried Triassic Landscape."

These repeated invitations to attend meetings of other societies in the city are much appreciated, and it is hoped that the Association will have before long the opportunity of returning the compliment.

EXCURSIONS.—Three excursions were held during the session, as follows :—

1911.

May 31—Woodlesford (Evening), for the examination of new sections in the Aire Valley Alluvium. Leaders: MESSRS. A. GILLIGAN, B.Sc., F.G.S., and E. L. HUMMEL, B.Sc.

June 17—Ingleton (by kind invitation of the Yorkshire Geological Society), for the examination of the Coal Measures, and Upper and Lower Permian Breccias. Leader: PROFESSOR P. F. KENDALL, M.Sc., F.G.S.

June 20—Roundhay Park (Evening) For the examination of sections of Millstone Grit, exposed in and near the park. Leader: MR. A. GILLIGAN, B.Sc., F.G.S.

The two evening excursions were well attended.

LIBRARY.—The publications of various societies and institutions come to hand as usual, and the library has been made use of by some of the members. Mr. Arnold Lupton continues his kind gift of the Quarterly Journal of the Geological Society, as published.

TRANSACTIONS.—Part 16 was issued to the members in December, and was favourably received by them and the local press. The sale of back parts has not been so large as might have been expected, considering the low prices at which these are offered to the members.

MEMBERSHIP.—During the session 5 ordinary members, 2 country members, and 5 associates have joined the Association. One associate has become an ordinary member. Two ordinary members have resigned, which leaves the roll as follows :

Honorary Life Members	8
Ordinary Members	87
Country Members	11
Associates	20

a total of 126, against 116 at the end of last session.

COUNCIL.—There have been 3 meetings of the Council, with an average attendance of 6.

Your Council cannot conclude its report without expressing the gratitude of the Association to those who have read papers, or exhibited specimens, slides, etc., at the meetings ; to the leaders of excursions ; to the Leeds Photographic Society, and the President of the Leeds Philosophical and Literary Society, for invitations to attend lectures ; to Mr. Arnold Lupton, and other donors to the Library ; to the University authorities for allowing the use of the rooms ; to Mr. W. Denison Roebuck, F.L.S., for auditing the accounts ; and to the members of the staff of the Geological Department of the University, whose generous assistance in various directions is one of the main factors in the continued success of the Association.

CASH ACCOUNT, 1912.

Cr.

Receipts.	£	s.	d.	£	s.	d.
Balance from last account				13	5	2
Arrears of Subscriptions				3	0	0
Subscriptions for 1911–12—						
64 Members	16	0	0			
6 Country Members	0	15	0			
13 Associates	1	12	6			
				18	7	6
Subscription for 1912–13				0	5	0
Sales of Transactions				0	11	3
Bank Interest				0	6	0
				£35	14	11

Dr.

Payments.	£	s.	d.	£	s.	d.
Printing of Syllabus, Notices, etc.				3	11	9
Postages				3	3	1
Stationery				1	2	9
Insurance of Books				0	2	0
Yorkshire Naturalists' Union				1	0	4
University of Leeds				2	2	0
Sundries				1	0	6
Cost of Transactions, part 16				11	10	6
Cash in Bank	10	18	3			
Cash in hand	1	3	9			
				12	2	0
				£35	14	11

BALANCE SHEET, 1912.

Assets.	£	s.	d.	£	s.	d.
Subscriptions Unpaid	6	10	0			
Less Paid for 1912–13	0	5	0			
				6	5	0
Cash in Bank	10	18	3			
Cash in hand	1	3	9			
				12	2	0
Books, Stock of Transactions, Stationery, etc.						
				£18	7	0

Liabilities.

NIL.

Examined, compared with Vouchers, and found correct,
May 10th, 1912.
W. DENISON ROEBUCK, Hon. Auditor.

SOME PETROLOGICAL CHARACTERISTICS OF UNDERCLAYS.

Paper read by MISS SARAH E. CHAPMAN, B.Sc., *November 17th*, 1911.

The term "underclay," or seat-earth, is applied to the rock, irrespective of its composition, which lies immediately beneath a coal seam. True underclays also occur in other positions, as, for instance, the rock above the Beeston Bed of coal, at Roundwood Colliery, near Ossett, which is indistinguishable from the underclay, below the coal. In place of coal a bed of carbonaceous shale rests upon it. Also, from the borehole at Selby, an ordinary shale was seen to pass gradually upwards into a true underclay, followed either by a very carbonaceous shale, or by a thin coal seam. The Estuarine Plant Beds of the Yorkshire coast rest upon a bed with all the characteristics of a Coal Measure underclay, as may be seen at Cloughton Wyke.

Underclays may vary from an exceedingly fine textured grey clay, the typical "fireclay," to a rock such as "gannister," which consists almost exclusively of quartz. The quantity of quartz varies between these extremes, but, however great may be the variation in mineralogical and chemical composition, all underclays possess certain common characteristics.

1.—All underclays show a remarkable absence of bedding planes, they break up into more or less rounded lumps, along curvilinear cracks, the surfaces of which are often highly polished by slickensiding.

2.—They are penetrated in all directions by rootlets, which in some cases can be traced to the roots of the plant. More rarely they contain impressions of rhizophores of *Sigillaria, etc.* These appear to be the only fossils present.

3.—Compared with analysis of ordinary Carboniferous shales, there is in underclays a relative or total absence of iron, calcium, magnesium, potassium, and sodium.

MINERAL COMPOSITION.

The most typical underclay is a soft grey clay with many rootlets, and considerable slickensiding in all directions. A cut face, after exposure to the atmosphere for some time, shows faint traces of bedding planes, but these are quite invisible in a fresh specimen. The rock is so fine-grained that it is impossible to distinguish individual minerals, or even to separate the different constituents. To the naked eye it appears a homogeneous mass.

From this commonest type, there may be a variation in two directions, in the amount of silica, or of carbonaceous matter present. 1.—The increase of silica is due to the coming in of free quartz to a greater or less extent. This is sometimes accompanied by an increase in the quantity of distinguishable mica present, and by increased coarseness of texture. The slickensiding of the more argillaceous rock becomes imperfect in these coarser ones, and is practically absent in the gannister type. Gannister represents the extreme of variation in this direction, it consists practically entirely of quartz. It may have a ferruginous cement, or the interstices between the quartz grains may be filled in with calcite, or in the less quartzitic ones by a fine paste of the micaceous mineral characteristic of the softer clays. In some cases the quartz grains interlock closely to the exclusion of any cement, and the only other material present is the carbonaceous matter of the rootlets.

2.—In the typical fireclay, there is little carbonaceous matter but every stage from this to an impure shaley coal can be seen. First the rootlets are marked out by a thin film of bright coal, instead of being mere impressions. The clay becomes darker by an increase of finely divided carbonaceous matter. Then thin irregular veins of bright coal appear in it—lenticular in form, and rarely persisting for more than a few inches, without any conspicuously parallel arrangement, either amongst themselves, or relative to the bedding of the coal above. Finally the rock becomes exceedingly carbonaceous, losing its slickensides to a great extent, and splitting

along the thin seams of coal with which it is interbedded, which may attain a thickness of a quarter of an inch. This phase passes into an impure coal, with shale partings, and finally into pure coal. In many cases this gradation can be seen in a thickness of a few inches.

Thin veins of iron pyrites are often present in the more carbonaceous underclays, and in such clays the slickensiding is less pronounced, and parallel to the bedding of the coal veins. The splitting of the clay along the faces of the strings of coal gives it an appearance of bedding.

The underclay of one coal seam varies in different localities. For instance, that of the Haigh Moor Coal at the Roundwood Collieries, Ossett, is a soft, grey clay, slickensided in all directions, with rootlets fairly abundant, some with a thin film of bright coal. At South Kirkby the seam is split into three members, each with its own underclay, the lowest one being rather harder and more sandy, with numerous thin veins of coal. The next one is a grey shale, with thin irregular streaks of carbonaceous matter, whilst the upper one is a darker grey shale, and more carbonaceous. At Ackton Hall Colliery the seam is undivided, and its underclay is a grey shale, with rootlets, passing upwards into a black shale with veins of coal of increasing thickness.

Microscopic Characters.

The structure of underclays can be studied under a low power objective, but to determine the mineral constituents, a higher power, and very thin sections are necessary. Here, again, is great variation. The dominant mineral appears to be an impure micaceous one, pale yellow in ordinary light, very faintly pleochroic. In extremely thin sections it appears colourless. Its double refraction is not so high as muscovite, and it extinguishes parallel to the long axis of the flakes, in which form it occurs. In some specimens this practically constitutes the whole of the rock.

Indeterminate very minute granules of a black opaque substance occur, also dark brown opaque patches, which may be dense hydrocarbons or resins, as these have been observed in comparatively large masses in lignite and bituminous coal (*F. W. Clarke, Data of Geo.-Chemistry*). A careful but unsuccessful search was made for heavy minerals such as zircon, rutile, and tourmaline. Some minute elongated sections of a colourless mineral, with a high refractive index were noticed, but not identified.

Next to the impure mica, quartz is the most important mineral present. With the exception of a few scattered angular fragments, some sections are practically free from it, whilst in others it is sufficiently abundant to form an argillaceous sandstone. One section showed alternating lenticles of micaceous and quartzose matter, with muscovite and a trace of biotite, the former being in comparatively large flakes, often bent around grains of quartz, quite colourless, with its boundaries sharply defined, and evidently of clastic origin. The biotite is in small, irregular and very ill-defined pieces, and may be of secondary origin. Undoubted clastic muscovite has been recognised only in sections where quartz is relatively abundant, and the rock is rather coarser in texture than the ordinary underclay. The quartz fragments of these rocks are comparatively large, and their angularity is rather remarkable. Two specimens of very quartzose rocks were examined. One was a gannister, composed of angular and sub-angular quartz grains, with a moderate amount of mica in the form of rather large flakes of muscovite, the cementing material apparently ferruginous, but obscured by large amount of carbonaceous matter present. The other specimen was of a rock which occasionally re-places that locally known as "clod," occurring immediately above the Beeston Bed coal at Roundwood, forming the underclay of a thin impure, shaley coal. It is practically a quartzite, the quartz grains sometimes interlocking, to the complete exclusion of any cementing material. In places the latter was calcite, due to infiltration, as the overlying coal is cut across in two directions by very fine joints,

lined with that mineral. In other cases, where calcite is present in the coal above, it does not appear to be present in the underclay where this is of the normal shaley type, no doubt due to its being more impervious than the quartzose rocks.

In the arrangement of its mineral constituents, an underclay shows considerable variations from ordinary shale. In sections of shale, cut perpendicularly to the bedding, the mica is seen to lie flat in one plane, but in specimens showing greater advance to purification and recrystallisation of the mica, this plane is crossed by strings of a minutely felted and wavy mass of the same mineral. Underclays show an almost exactly opposite structure. Where there was any trace of bedding, most sections cut perpendicular to it failed to show any conspicuous parallel arrangement of the micaceous mineral. In the less carbonaceous clays the minute flakes of mica were orientated in all directions. With crossed nicols the amount of extinction was even in all positions. But across this field of differently orientated flakes could be seen streaks wherein the mica showed a distinctly parallel arrangement amongst the flakes themselves, but not always parallel to the direction of the streak. As in hand specimens where an increase of carbonaceous matter brings an increased parallel structure, giving an appearance of bedding, so in cut sections, such clays show a greater tendency to a parallel arrangement of the minerals. When the section is crossed by numerous parallel veins of coal, the mica runs parallel to them, and, under crossed nicols the whole of it practically extinguishes simultaneously. It seems, therefore, that some connection exists between the quantity of carbonaceous matter, and the parallelism of the micaceous mineral. The quartzose types of underclay show little tendency to any parallel arrangement.

Chemical Analyses.

A series of six underclays from the Roundwood Collieries, varying from one consisting exclusively of the impure mica, to an almost pure gannister, has been analysed, but only the more im-

portant constituents, silica, alumina, ferric oxide, lime, magnesia, potash, and soda, have been determined. The loss in weight on heating, due chiefly to water and carbon, has been deducted, and the percentage of the other constituents re-calculated without them, to facilitate the comparison of rocks containing very variable quantities of carbon. To extend the comparison, analyses of six typical Carboniferous shales, by Mr. Hutchings, are appended, but no loss of weight on ignition is deducted.

Analyses of Underclays from Roundwood Collieries :

	1	2	3	4	5	6 (stone)
SiO_2	68.26	62.86	44.77	57.82	72.58	89.46
Al_2O_3	28.19	32.07	46.84	36.48	19.13	3.34
Fe_2O_3	1.29	1.46	3.39	3.68	2.33	
CaO	2.58	2.59	2.84	2.34	2.39	5.19
MgO	0.43	1.55	2.37	0.24	0.34	1.36
K_2O	1.06	0.98	1.12	1.06	1.46	trace
Na_2O	0.33	0.31	0.45	0.20	0.53	trace
Loss on ignition	9.11	8.21	28.3	13.46	6.39	14.72

Analyses of normal Carboniferous Shales.

	1	2	3	4	5	6
SiO_2	66.30	59.28	56.85	59.25	53.57	54.46
Al_2O_3	18.95	21.85	24.58	21.93	24.53	23.75
Fe_2O_3	4.35	5.80	5.30	5.65	6.51	6.8
CaO	0.60	0.45	0.52	0.55	0.76	0.85
MgO	1.04	1.24	0.94	1.42	1.81	1.78
K_2O	3.18	4.13	3.78	4.21	4.34	4.54
Na_2O	0.54	1.18	1.44	1.08	0.97	0.89
Water	5.35	6.25	7.15	6.21	7.65	7.53

A comparison of the two tables shows :—

1.—A considerable decrease in the quantity of the iron in the underclays.

2.—An increase in the quantity of lime. In the case of the "stone" the large quantity of lime is due to infiltration of secondary calcite. Since no calcite has been detected in any other of the clays, the lime in these must be present in combination with the impure micaceous mineral.

3.—A decrease in the soda and potash. The whole of these was not extracted, but there is a considerable decrease, from 4% to 1% in the latter, and 1% to less than ·5% in the former.

4.—The loss on ignition is much greater in the underclays than in the shales, due to the presence of carbonaceous matter in the former.

The analyses of the underclays corroborate the microscopical examinations of the sections in an interesting way. Reference to the figures will show that there is an antipathetic variation in the amounts of silica and alumina present, due to the fact that an increase in the amount of free quartz brings with it a decrease of the micaceous mineral, which approaches pure aluminium silicate in composition. The percentage of lime maintains a remarkable constancy, except in case of the "stone," which has been explained.

Origin of Underclays.

The observations here recorded make it clear that underclays are special modifications of normal Coal Measure Shales, most of which are of non-marine origin. All these sediments were deposited in a slowly subsiding area, and the pressure of superincumbent deposits would develop a fissile structure along the bedding planes, the mineral particles tending to lie in this plane. In turn, a gradual uplift resulted in a land surface, probably swamp, in which grew the dense mass of vegetation destined to form the overlaying coal seams, these processes being repeated many times. The roots of the plants penetrating the soil, destroyed any laminations, previously formed, and prevented the formation of any

parallel structure in it. That the underclay was the actual soil on which the coal-forming plants grew, apart from the abundance in many cases of the roots themselves, is further proved by the extraction of the iron and alkalies.

THE AMMONITES OF THE LIAS.

Abstract of Paper read by MR. C. THOMPSON, B.SC., *December 15th,* 1911.

Since the Ammonite is quite extinct, and none of its soft parts have been preserved, it is not exactly certain what the animal was like, but it must have been a mollusc very like the Nautilus of the present day, for it inhabited a shell very similar to the one of that animal. As now found in the rocks the Ammonite is only a cast of the shell, more or less completely preserved. The shell of the Nautilus is coiled in a plane spiral, which is divided by a series of curved walls, known as the septa, which are smooth, and concave towards the mouth of the shell, meeting the outer wall, and making with it a smooth, undulating line of contact, known as the suture line. Each septum is pierced at the centre by a tube—the siphuncle, which is given off from the body. The animal lives in the last chamber, attached by muscles to its walls. A section of an Ammonite shows a similar structure, except that the septa are fairly concave near the central line of the chambers, but are more or less crumpled where they meet the walls ; and the position of the siphuncle is quite different. The suture lines are only seen when the shell is removed, and are of great value in differentiating the various genera. The various species have their shells ornamented with folds more or less beautiful, and many are armed with tubercles or spines. Some have a smooth venter, (or back), whilst others have a sharp keel, and some have one or two furrows on the venter.

The question has arisen lately as to whether the shell of the Ammonite is an internal, or an external one. Its close relationship with Nautilus, which shell is certainly external, and the fact that (1) Mr. Crick and others have described the muscle impressions by which the animal was attached inside the shell are very strong arguments in favour of its being an external shell. No internal shells are so ornamented, but the exponents of the internal theory

say—look at Spirula and Argonauta. The former must be taken as an internal shell, but it has no ornamentation, and the latter is certainly an external shell, with very obvious ornamentation. It has also been said that the wonderful power of repairing a damaged outershell, as shown by the Nautilus, razor-shell, and others, has never been shown in an Ammonite, but here is a specimen showing it clearly. Many specimens have been found in Germany, distorted by the growth upon them of the tube-secreting Serpulæ, which are undoubtedly external, and quite recently such a specimen was found near Withernsea. There is only one point against the external character of the shell that is not yet cleared up, that is the uncoiling which produced such abnormal forms as *Hamites* and *Scaphites*, before the race died out.

When did the first Ammonite—like animals first appear? The evolution of the race began far back in geological times. Goniatites first appear in the Devonian, and from that system onwards there is a progression of forms, until the first abundant development of the Ammonites themselves in the Alpine Trias. In Britain they are confined to the Jurassic and Cretaceous rocks. These islands have been peopled by successive masses of people from the east, one race after another arriving, and re-placing or dominating the one in possession. Just as the Kelts, Romans, Saxons, Danes, and Normans successively held their sway, so it is found the races of Ammonites succeeded one another in waves of migration, which first reached our own district in early Liassic times. Whilst in Triassic times the area which is now Britain was a desert region, with great salt-lakes, there existed in what is now Central Europe and the Mediterranean area, an open ocean, with abundant life of many forms, amongst them Ammonites, which were the stock from which the British ones were derived. Towards the close of the Trias the open sea gradually transgressed over the land to the north and west, slowly spreading through what is now France and Germany, until it finally covered much of what became the British area, and even sent out its arms far towards the Pole.

The incoming waters brought their inhabitants, and as soon as the conditions became favourable for their existence, the first Ammonites arrived, creeping along the coast-line of the period either by way of North Germany, or, as is generally believed, passing round the island formed by the Ardennes, and the London ridge. The first of them to arrive were of plain form, little forecasting the wealth of ornament, and abundance of individuals which were to follow. The earliest is *Psiloceras planorbe*, which is essentially a smooth form, though not absolutely so, as the inner and therefore younger whorls are slightly corrugated by low pilæ, costæ, or ribs, which are invisible on the outer whorls, being replaced by what are probably mere growth lines. The cast is usually quite smooth. The venter shows no traces of keel or furrows. So many of our Ammonites are smooth when young that (2) Hyatt considers *P. planorbe* as the radical stock from which many of the Lower Liassic forms are derived, though (3) Mr. Buckman does not agree with this. The suture lines are distinctive, but simple in form, and, owing to the method of preservation of the northern specimens, they often are beautifully shown. The range in time of this species was very limited, but it had a wide geographical distribution. It is rarely found *in situ* in Yorkshire, (4) Tate and Blake record it from Eston and Coatham, many years ago; but it is found in blocks washed up by the sea, and in the Drift.

There is another species, *P. plicatus*, so stoutly corrugated that when a longitudinal section of the shell is seen, it is quite wave-like in form. It is common in Germany, but the writer has only been able so far to find one specimen in a very poor state of preservation.

P. Hagenowi, Quenstedt, is another early form, supposed by Hyatt to be a degenerate *planorbe* reverting to a Triassic type, but here again opinions differ. The first specimen found in England, from the Drift, was exhibited, and its suture lines resemble those

of *Ceratites* of the Trias. It is recorded from the lowest Lias of the N.E. Alps, Switzerland, Bohemia, and N. Germany, but has not been found *in situ* in Britain.

Caloceras Johnstoni arrived with *P. planorbe*, and survived it, living on through the succeeding zone. Its whorls are rounder, but the venter is still smooth and rounded. On the flanks are well-marked pilæ, which are short rounded elevations confined to the side of the whorl, but not encroaching on the smooth venter or umbilical edge. Its suture lines are similar to those of *P. planorbe*, but, if it was derived from the same stock, it is a more vigorous offshoot.

The next immigrant was *Schlotheimia angulata*,—a very neat form, widely distributed, but with a very limited time range. It is distinguished from all other species by its neat, compressed whorl, and well developed pilæ, which are very regular, and bend well forward to the mouth as it to meet in the central line of the venter in an angle, but they are suppressed before meeting, and dying out suddenly, form a groove.

Whilst *C. Johnstoni* and *S. angulata* held sway there came along the pioneer of a great incursion by an entirely different family of Ammonites, with well-marked keels and furrows on the ventral side. The earliest species is *Arietites Conybeari*, and this race dominated our area for a considerable period.

Many other Yorkshire Liassic Ammonites were illustrated, and their characteristics described.

REFERENCES.

(1) Crick, G. C. "On the Muscular Attachment of the animal to its shell in some Fossil Cephalopoda (Ammonoidea)." Trans. Linn. Soc. (1898). Second Series, Zoology. Vol. VII., Part 4.

(2) Hyatt, A. "Genesis of the Arietidæ." Smiths Contrib. Knowledge. (1889). No. 673, p. 117.

(3) Buckman, S. S. "On the Grouping of some Divisions of so-called Jurassic Time." Q.J.G.S. (1898). Vol. 54. Part 3, p. 445.

(4) Tate and Blake. "The Yorkshire Lias." (1876).

"EVIDENCES OF CLIMATIC CHANGES IN GEOLOGICAL TIMES."

Abstract of Paper read by PROFESSOR P. F. KENDALL, M.Sc., F.G.S., *February 16th*, 1912.

The principal elements of climate that might be recorded in the rocks are temperature, humidity, and wind directions and velocity, and, therefore, distribution and barometric pressure. The evidences may be physical and biological, the former being the more trustworthy, when properly investigated As regards temperature, biological evidence is not often reliable, though some physiological adaptations may be. The fact of the remains of elephant and rhinoceros with a woolly covering, having been found, proves that these animals were able to adapt themselves to a cold climate, whereas experiments have failed to acclimatise the reindeer in Britain. Crocodiles and turtles, as well as other cold-blooded creatures, depend upon sun-heat for the incubation of their eggs; therefore the occurrence of the remains of such animals may be evidence of high temperature. Genera are usually of no value whatever as climatic indices. For instance, the Canis family may be represented either by the Arctic fox or the Indian jackal, and even species do not furnish decisive evidence as to climate. The tiger ranges from the burning plains of Bengal to cold Siberia, where it preys upon the reindeer. The puma ranges from Patagonia, in the South of the American Continent, to Alaska in the North. In Xenophon's day the lion lived in Greece. It is now a beast of the sandy tropical plains, but in Pleistocene Britain it was probably a forest dweller. The carnivora, which only need flesh food, the nature of the prey being immaterial, afford less valuable evidence of climate than the herbivora, and these latter are not always decisive. Remains of hippopotamus have been found in England, associated with those of food plants of common prevailing British species.

Marine life does appear to be closely controlled by temperature,

but here the idiosyncracies are specific rather than generic Whilst temperature appears to be the dominant factor, barriers, isolation, and competition exert their influences The range of many tropical molluscs such as Voluta, Oliva, and Nautilus, is limited by temperature, as is that of the reef-building corals, though with these latter, such may not always have been the case, as the old reef-builders are only in part similar to those of the present day Some naturalists have argued that the large size attained by some species is due to warm conditions, but recent marine explorations disprove this. For instance, Pleurotoma is much larger in the arctic than in the tropical seas, and the largest Terebratulæ are found in cold water.

Botanical evidence of climatic change is dependent on many factors,—duration and intensity of light; soil; humidity; temperature; shelter; insect visitors; and injurious mammals. It might be inferred that the absence of annual rings of growth from early fossil trees is evidence that the seasons did not then exist, or exert any influence, until comparatively recent times, as such rings are not known before the dadoxyfon of the Falkland Isles The mere darkness of the Polar winter would not inhibit the spread of arborescent plants, for in the dark winter of St Petersburg tropical plants survive in greenhouses if kept warm. But whatever evidence of local climatic conditions may be furnished by fossil plants, except those which have unmistakeably grown where found, it is not very conclusive, as the plants may have been drifted for very considerable distances. The roots of trees show the direction of the prevailing winds by a strengthening on the windward side, and a careful study of such fossil evidence as may be available from time to time may furnish useful indications as to wind direction and velocity in past geological times. Such observations as have been made show that wind velocities were no greater ages ago than now.

Coming to physical intimations of climates, the speaker said

that only extremes of temperature were recorded in the rocks, heat not being so well recorded as cold, the latter being more widely distributed. Other assumed signs are more of dryness and dessication, than of heat *per se.* Glaciation is the best-known sign of temperature, but it needs very careful consideration. Boulder beds are often regarded as evidence of ice action, but in some cases they are due to different causes. In many granitic areas the surface weathers into boulder-like forms. Many of the boulders on the coast of North Yorkshire obviously are not due to glacial action. Neither is a hummocky surface always due to such a cause, as, for instance, that of the Mount Sorrel area, which underlies a desert deposit. Scratched rocks, even, are not always evidence of ice action, as not only are cases known of these being due to earth movements, but boulders on a rough coast, as at Peak, acquire planed and striated surface by mutual attrition during heavy weather.

Wind direction may be indicated by other means than by plants. The Penrith sandstone is clearly a consolidated wind-borne desert sand, the form of the grains is characteristic of such formation; they have apparently been derived from the Millstone Grit of the Pennines, and these inferences if correct carry the further implications of arid conditions with prevailing winds from the east. Further proof of this is seen in the dune-bedding of these rocks, which is from east to west. The Pliocene beach deposits of East Anglia contain great accumulations of shells—the beds of the same age at the opposite side of the North Sea do not, whilst, to-day, the position is reversed. This, according to Mr. Harmer, proves a reversal of the prevailing on-shore winds, those of Pliocene times evidently having been easterly. In studying the Dolomites, Skeat found evidence of wind direction in the deposits of volcanic ash and dust.

The earliest definite indication of climate known is in Canada, where the basal member of the Huronian is a bed of 'tillite,' or

hardened boulder-clay, containing boulders of still older rocks, well striated, and resting upon an unmistakeable glaciated surface. This tillite is found over an area stretching 1000 miles from east to west, and 700 miles from north to south. In some places recent boulder-clay rests upon this immeasurably older one, including fragments of it, as boulders. It is possible to extract from the modern glaciated surface stones whose underside received their polish and striæ in the Lower Huronian, while their upper surface has been smoothed and scratched by Pleistocene ice movements. Dr. Strahan has observed boulder-clay similar to the Huronian in the Varanger Fjord, resting on a glaciated surface of quartzite, of pre-Cambrian age. In South Australia there is an ancient boulder-clay, probably of pre-Cambrian, or early Cambrian age, extending over an area of thousands of square miles. The fact that rocks well above it yield an Olenellus fauna indicates its vast age.

Coming up the geological scale, many geologists now consider the Old Red Sandstone to be of desert origin, and salt having recently been found in it supports this conclusion. There was wide-spread glaciation over the southern hemisphere in Permo-Carboniferous times. It was first detected in South Africa, where, at the junction of the Vaal and Orange Rivers, a genuine boulder-clay was found, with scratched boulders resting on a clearly glaciated surface. The direction of the striæ, and the nature of the boulders, proved an ice-flow from the north. Later, a similar deposit was found in India, on the same horizon, and it has since been found in Tasmania, Victoria, South Australia, Queensland, Graham Islands and the Falkland Islands, and probably in Brazil and the Argentine. At about this same period there was an interesting climatic phase as represented in the Permian and Triassic rocks. In the North-west Europe and Eastern America arid deserts and desert lakes prevailed, changing to marine conditions, towards on the one hand Western America, and on the other in Southern Europe and Western Asia.

It was not until Jurassic times that the influence of latitude produced unequivocal effects in the rocks. The fossils of that period prove three or, according to some authorities, four distinct climatic zones, north of the Equator. There were coral reefs, even in Yorkshire, in late Jurassic times, but in the Cretaceous period the reef-building corals seem to have been compelled to migrate farther south, and in Tertiary times, this was accentuated. The Tertiary climate was at the outset warmer than now, almost throughout the world. There was a general lowering of temperature through Oligocene, Miocene, and Pliocene, culminating in the last glacial period which, judging from all the available evidence, appears to have been universal and simultaneous.

ANNUAL REPORT,

1912-13.

Presented and adopted at the Annual Meeting, May 16th, 1913.

YOUR Council has once more the pleasure of reporting that the work of the Association has been carried on with continued success, in every way, during the session just closing. The membership is well maintained, there has been no difficulty in obtaining suitable papers for the meetings, some of which have given rise to useful discussions, whilst the exhibits have been numerous and interesting. The meetings have been well attended. The financial position of the Association is quite sound, there being a substantial cash balance to its credit.

MEETINGS.—The usual eight evening meetings have been held, as follows :—

1912.

Oct. 18—Opening Meeting of the 39th Session.

PRESIDENT'S ADDRESS—"Geological Problems of the North-west Highlands, and their Solution."

EXHIBITS—Lantern slides, maps, rocks, and rock sections, illustrating the President's Address.

The splendid case of coals, coal sections, and photographs of coal, recently presented to the University by Dr. W. E. Garforth.

The latest maps and memoirs of the English and other geological surveys.

By MR. M. ODLING, M.A., B.Sc., F.G.S. : A large series of lantern slides of Jurassic fossils.

By MR. H. L. STEPHENSON : A complete fossil fish from the Coal Measures, Askern.

By MR. E. HAWKESWORTH : Specimens of rocks and minerals from Shap. Marine fossils from the Millstone Grit of the Masham

area: (a) Cayton Gill Beds. (b) Marine Band 250ft. lower. Fossils from Marine Band in Coal Measures, Askern.

By various members and associates: Fossils, etc., from Askern.

Nov. 15—MR. A. CHARLESWORTH, M.Sc., read a paper on "A Holiday in the Pyrenees" (*illustrated by rock specimens, and lantern slides*).

MR. GODFREY BINGLEY exhibited series of lantern slides illustrating geological features in the Settle district, and Robin Hood's Bay, also the geology of the Appleby and Shap districts, which were described by the President.

MR. ARTHUR BURNET exhibited a fine piece of fossil wood from the Neocomian Clay, Spilsby.

Dec. 13—MR. M. ODLING, M.A., B.Sc., F.G.S., read a paper on "The Upper and Middle Oolites of England and North-west France, with special reference to the Kimmeridge Clay and Corallian" (*illustrated by a fine collection of fossils, and lantern slides*).

MR. A. BURNET exhibited fossils from the Oolite, Malton.

1913.

Jan. 17—MR. C. H. GRANT, M.Sc., F.R.Met.S., read a paper on: "The Influence of Atmospheric Pressure on the Earth's Crust."

Feb. 21—DR. A. WILMORE, D.Sc., F.G.S., read a paper: "How some of our Limestones have been formed" (*illustrated by diagrams, specimens, and a series of lantern slides showing sections of Carboniferous Limestone*).

Mar. 14—PROFESSOR P. F. KENDALL, M.Sc., F.G.S. gave an address: "A Review of Carboniferous Geology."

An oak roll-top desk, attaché case, and illuminated address were presented to Mr. E. Hawkesworth, in recognition of his having completed 25 years' service as an official of the Association, and a gold pendant was presented to Mrs. Hawkesworth.

Apr. 25—MESSRS. A. BURNET and J. H. EVERETT, B.Sc., contributed a detailed account of the results of the investigation of the sections exposed in the Robin Hood Quarries, near Wakefield. This was illustrated by lantern slides from photographs made by MR. F. ELLISON, B.Sc., by diagrams, and a large collection of fossils.

MR. A. BURNET contributed a short note on "Chalk Pebbles from the English Channel," which was illustrated by microscope slides, lent by MR. A. J. JUKES-BROWNE, B.A., F.R.S.

May 16—Annual Meeting. Adoption of Annual Report and Financial Statement, and election of officers.

MR. M. ODLING, M.A., B.Sc., F.G.S., exhibited a working model of a geyser, also a large collection of Fullonian rocks and fossils from the cuttings of the G. N. Ry. from Essendine to Corby, with sections of the cuttings.

MR. A. BURNET exhibited fossils from the Cenomanian beds of the South of England; micro-slides of Miocene limestone from Malta, fossils and micro-slides of Magnesian Limestone from Garforth; and calamites from the Leeds Patent Brick Works.

MR. E. HAWKESWORTH exhibited fossils from the Kelsey Hill Gravels, Holderness, and from gravels at Hunstanton.

The average attendance at these meetings was about 35.

On March 4th, by the kind invitation of the President of the Leeds Philosophical and Literary Society (Professor P. F. Kendall, M.Sc., F.G.S.), a large number of our members attended a lecture before that Society by Sir Thomas H. Holland, K.C.I.E., F.R.S., on "Systematic Study of a Great Earthquake."

EXCURSIONS.—Seven excursions have been held during the session, as follows:—

1912.

Oct. 12—Askern, for the examination of glacial deposits, Trias, Permian, and Coal Measures. Leader: MR. H. CULPIN.

June 18—(Evening) to Robin Hood Quarry, Coal Measures, Leaders: MESSRS. A. BURNET and J. H. EVERETT, B.Sc.

June 22—To Knaresborough. Magnesian limestone, Millstone Grit, and the Nidd gorge. Leader: MR. A. GILLIGAN, B.Sc., F.G.S.

July 18—(Evening) To the Leeds Steel Works, for the examination of the iron ores used.

1913.

May 21—To Roundhay. Coal Measures, Rough Rock. and faults. "A simple exercise in geological mapping." Leader: PROFESSOR P. F. KENDALL, M.Sc., F.G.S.

June 7.—Micklefield. Magnesian Limestone. Leader: MR. A. GILLIGAN, B.Sc., F.G.S.

June 12—Burnsall and district. Lower Carboniferous. Leader: DR. A. WILMORE, F.G.S.

These excursions have been better attended than usual. As a result of that to the Robin Hood Quarries, a detailed survey has been made, which will be published in the next part of the Transactions. Following upon this the members of the Association should undertake the task of putting upon permanent record the details of all sections, temporary or otherwise, exposed in or near Leeds.

LIBRARY—The publications of various societies and institutions are received, as usual, and the books have been made use of by some of the members. Mr. Arnold Lupton continues his valuable gift of the Quarterly Journal of the Geological Society.

TRANSACTIONS.—Part 17 is in hand, and it is hoped to publish it towards the end of this year. Members are urged to supply themselves with the back parts, which contain much valuable local information, and may be obtained at an exceedingly low price.

MEMBERSHIP.—During the session 4 ordinary members, and 10 associates have joined the Association. Two members have been struck off the list owing to non-payment of subscriptions. Six members, on leaving the district, have become country members, and 8 members and 2 associates have resigned. Mr. Gilbert Y. Tickle was killed whilst engaged in rescue work at the Cadeby Colliery disaster, July 1912. Messrs. Stanley Nettleton, and Ernest Parsons, active members of the Association, have been appointed to posts in South Africa and India respectively, and were assured

of the good wishes of their fellow-members before leaving Leeds. The membership roll is now as follows :—

Honorary Life Members	8
Ordinary Members	74
Country Members	16
Associates	27

a total of 125, against 126 a year ago. The list of ordinary members tends to dwindle, and efforts should be made to obtain more, as the subscription is quite small, and the privileges of membership great.

COUNCIL.—There have been two meetings of the Council with an average attendance of 7.

In conclusion, your Council desires to place on record the gratitude of the Association to those who have read papers, or exhibited lantern slides, specimens, etc., at the meetings ; to the leaders of excursions ; to the President of the Leeds Philosophical and Literary Society, for his kind invitation to the members to attend Sir T. H. Holland's lecture ; to Mr. Arnold Lupton and other donors to the Library ; to the University authorities for granting the use of the meeting rooms ; to Mr. W. Denison Roebuck, for auditing the accounts ; and to the members of the staff of the Geological Department of the University, whose unstinted services in many ways, contribute in a very marked degree to the continued success of the Association.

A sub-committee has been appointed for the purpose of placing on record geological particulars of the sections that will be exposed in the making of the new main sewer, which will cross the city from its western to its eastern boundary.

CASH ACCOUNT, 1913.

Cr.

Receipts.	£	s.	d.	£	s.	d.
Balance from last account				12	2	0
Subscriptions, Arrears				4	10	0
Subscriptions, 1912–13—						
58 Members, 5s.	14	10	0			
11 Country Members, 2s. 6d. (less difference in exchange) ..	1	7	5			
14 Associates, 2s. 6d.	1	15	0			
				17	12	5
Subscriptions, 1913–14				0	7	6
Subscription, Life Member				1	5	0
Re-prints				1	5	0
Bank Interest				0	6	3
				£37	8	2

Dr.

Expenditure.	£	s.	d.	£	s.	d.
Printing of Syllabus, Notices of Meetings, etc.				4	2	0
Postages				3	13	5
Stationery				1	8	0
Sundries				1	2	6
Insurance of Books				0	2	0
Transactions, parts 1 and 2 bought ..				0	3	6
Transactions, re-prints				1	5	0
Gas for Lantern				0	7	8
Yorkshire Naturalists' Union				1	0	2
University of Leeds				2	2	0
Cash in Bank	19	7	0			
Cash in hand	2	14	11			
				22	1	11
				£37	8	2

BALANCE SHEET, 1913.

Assets.	£	s.	d.	£	s.	d.
Subscriptions Unpaid	6	10	0			
Less Paid in advance	0	7	6			
				6	2	6
Cash in Bank	19	7	0			
Cash in hand	2	14	11			
				22	1	11
Stock of Transactions, Books, and Stationery (of considerable value)						
				£28	4	5

Liabilities.

NIL.

Examined, compared with Vouchers and found correct.
10th May, 1913.
W. DENISON ROEBUCK, Hon. Auditor.

NOTES ON SECTIONS IN A QUARRY AT ROBIN HOOD, NEAR LEEDS.

By ARTHUR BURNET, *and* J. H. EVERETT, B.Sc.

The sections described in the following article are exposed in the Robin Hood Quarries of Messrs. Geo. Armitage & Sons, Ltd., about four miles south of Leeds. The beds belong to the Middle Coal Measures.

A reference to the six-inch Geological Survey map of the district (Sheet 233) will show the Thorpe Wood fault running across this part of the country for several miles, having been observed at Beeston Manor Colliery in the east, and traced in a westerly direction to Rothwell and Carlton. It has a throw of about 500 feet, with a considerable hade to the southern or downcast side.

Two very deep stone quarries at Robin Hood just on the northern side of the fault show a fine succession of beds of massive sandstone, with small interstratifications of a more shaly character. These beds represent the "Thornhill Rock," they contain *Calamites* and other plant remains, whilst another interesting feature is the inclusion of enormous concretions more or less spherical in shape, some of them weighing upwards of a ton. There is another quarry a little to the south of the above which showed the fault itself, but it is now disused, and the section is becoming rapidly obscured (1914).

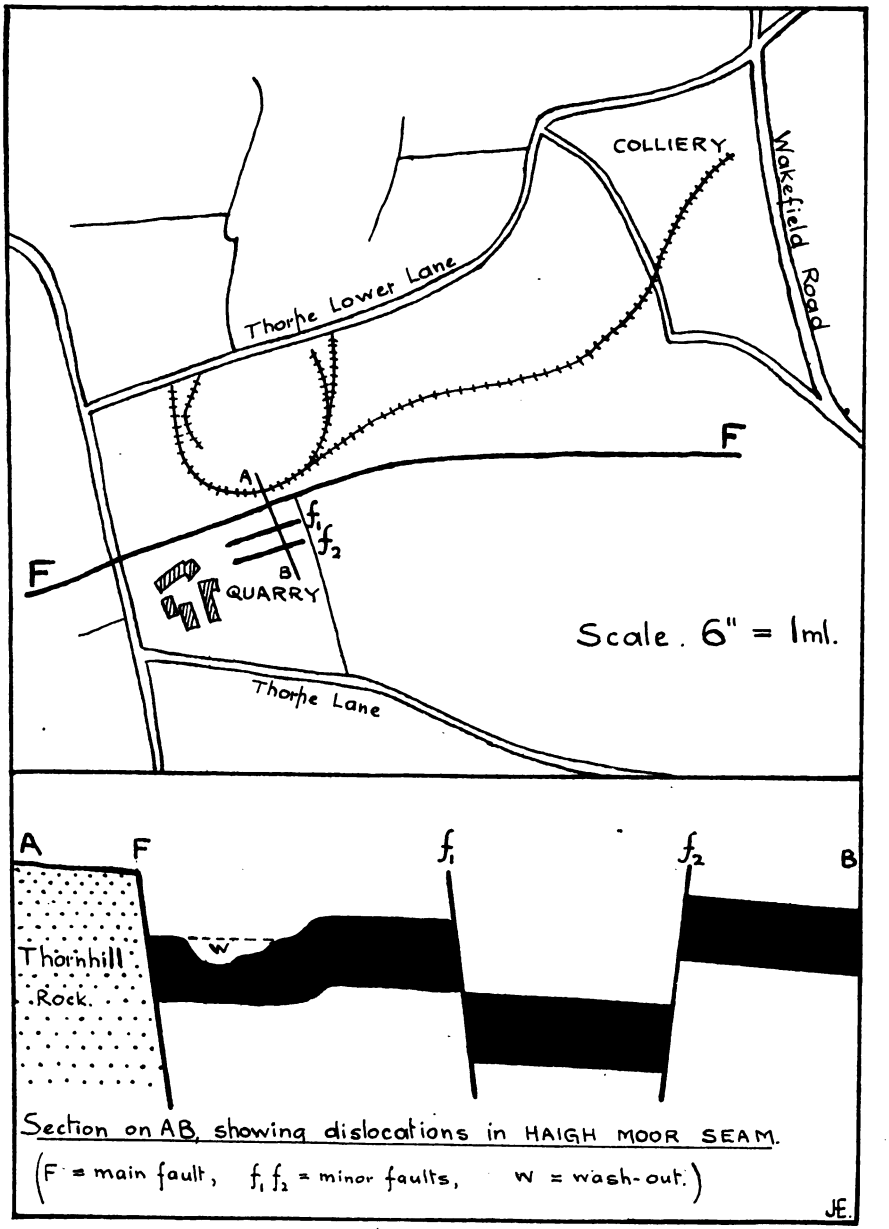
Immediately to the south of the fault is the large quarry which is worked for brickmaking purposes. It exhibits a striking series of subsidiary faults running parallel to the main fault, in a direction which is here W.S.W.—E.N.E. They are shown with unusual clearness along the eastern face of the quarry, and can readily be traced across to the western side, although the amount of throw rapidly decreases in this direction. The dip of the beds is nearly due south (i.e., the strike is parallel to the faults) and amounts,

at the northern end of the quarry, to 6°, but to the south of the fault marked f2 the beds are more nearly horizontal—the dip being only about 2°.

The lowest bed exposed is a firm light-grey shale containing ironstone nodules, somewhat irregularly distributed. The uppermost 4ft. of this deposit is crowded with stigmarian rootlets. This is followed by a seam of coal 6 inches in thickness, above which occurs 2ft. of soft grey shale, very carbonaceous, near the centre of which is a very thin but persistent layer of coal. The shale is full of plant remains, but these are usually indeterminable. Above this lies the Haigh Moor coal, in which an interesting "wash-out" was exposed in 1912, nearly at the north-eastern corner of the quarry. (Fig. 7) The monoclinal fold between w and f, on Plate No. 1 is extremely well marked in these beds. (Plate 6)

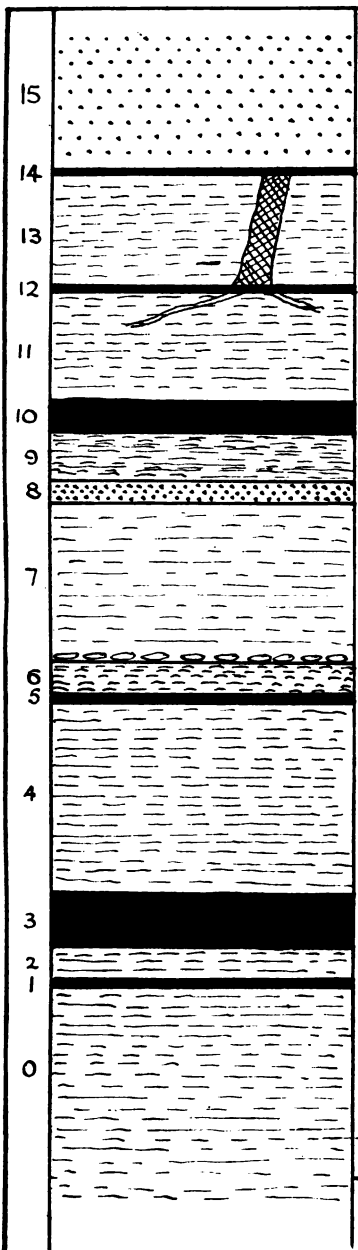
The shale which overlies the Haigh Moor coal is crowded with well-preserved plant remains, and in 1912 an erect tree trunk (*Lepidodendron*) about a foot in diameter was exposed. Ironstone nodules occur here in great numbers and are fossiliferous. The upper part of the stratum is crowded with rootlets. It will be noted that the fault marked f1, brings this bed into juxtaposition with the Haigh Moor coal, and an exposure here in the spring of 1914 showed the fault face covered with slickensided shale.

Above this shale comes another six-inch coal seam, followed by 2ft. of brittle black shale, containing some plant remains, and obscure impressions of mollusca (*Carbonicola?*). Ironstone nodules also occur, but these appear to be unfossiliferous. The top of the shale is marked by a closely packed floor of nodules, above which is 10ft. of very hard grey shale. Nodules occur in this shale, and an exposure near the southern end of the quarry showed them somewhat sporadically distributed throughout the beds. More recently however (1914) the shale has been worked along the eastern face of the pit, and here the nodules are packed together



— ROBIN HOOD QUARRIES —

Trans. Leeds Geol. Assoc., part 17, plate 1, fig. 1.



	FT. INS.	
15	10 - 0	– Sandstone (Argillaceous in places)
14	0 - 4	– Coal: underlain by 4" soft yellow clay (rootlets)
13	6 - 0	– Light grey Shale - firm - plant remains - tree trunks (photo) rootlets.
12	0 - 4	– Coal
11	6 - 0	– similar to Bed 13 – no trees found – rootlets – nodules.
10	2 - 0	– Coal - poor
9	3 - 0	– Soft dark grey Shale – rootlets – a few nodules.
8	1 - 6	– HARD SANDSTONE. a few Calamites.
7	10 - 0	– Firm grey Shale – continuous layers of nodules (mollusca) – septarian nodules.
6		Continuous layer of nodules at base [cf. No. 7]
5	2 - 0	– Friable black Shale.
	0 - 6	– Coal.
4	12 - 0	– Grey Shale – abundant Plant remains (in Shale & nodules) – rootlets towards top.
3	3 - 6	– HAIGH MOOR COAL (Wash-out)
2	2 - 0	– Soft grey friable Shale – much Carbonaceous matter – 1" Coal parting
1	0 - 6	No. 1 – Coal. – 4" soft yellow clay above 2" " " " below
0		– Grey Shale (not yet worked to base) – rootlets in top 4 ft.

JE

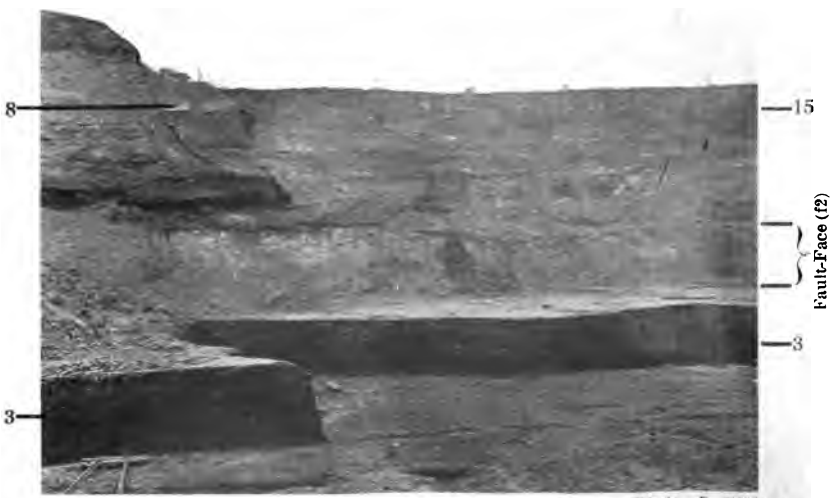
(TO SCALE.)

—GENERAL SECTION at ROBIN HOOD.—

Trans. Leeds Geol. Assoc., part 17, plate 2, fig. 2.

Photo—F. Ellison.

Fig. 3. Robin Hood Quarry.—Looking East.—Showing Haigh Moor Coal between f1 and f2. (Compare Fig. 4).



Photo—F. Ellison

Fig. 4. View across Robin Hood Quarry, looking South, across f2 Haigh Moor Coal in trough fault. (Compare Fig. 3).

Photo—F. Ellison.

Fig. 5. Robin Hood Quarry.—Showing Trough Fault, Looking N.E.

Photo—A. Charlesworth.

Fig. 6. Robin Hood Quarry.—Showing up-turned edge of Haigh Moor Seam at f1 (slightly to right of centre).

Photo—F. Ellison.

Fig. 7. Wash-out in Haigh Moor Seam in Robin Hood Quarry.

Photo—H. Crowther.

Fig. 8. Robin Hood Quarry.—Tree Trunk and Roots. (Compare Fig. 2).

Photo—H. Crowther.

Fig. 9. Robin Hood Quarry.—Monoclinal Fold (or Incipient Fault) in Haigh Moor Seam. (See Fig 10).

Photo—H. Crowther.

Fig. 10. Robin Hood Quarry.—Monoclinal Fold (Incipient Fault) in Haigh Moor Seam. (Nearer view of Fig. 9).

in quite continuous horizontal layers a foot or two apart. Large septaria, with veins of calcite, also occur in this bed. Plant remains are not abundant, but a few calamites are found. A few specimens of mollusca have also been obtained from this stratum. Overlying this is a bed of hard grey sandstone, 18 inches in thickness, which breaks out in massive blocks, and forms one of the most conspicuous beds in the quarry. It passes up gradually into a hard sandy shale 6 to 12 inches in thickness, this being succeeded by 2ft. 6in. of soft dark grey shale, containing a few nodules, and full of rootlets. Above this occurs a seam of coal, 2ft. in thickness, followed by 6 feet of hard grey shale, which has yielded some very fine plant remains. There are a few nodules, some of them containing fossils. A thin seam of coal divides this bed from the one above, which is almost identical in lithological character, and fossil contents. Fine specimens of erect tree trunks are frequently exposed in the upper bed, the roots passing through the coal into the stratum below. (Fig. 8) Rootlets are very plentiful immediately below the coal. Another thin coal seam occurs at the top of the higher bed of shale, the coal being underlain by a thin stratum of yellow clay full of rootlets. The highest bed exposed in the quarry is a rough argillaceous sandstone, which contains few fossils, although one or two tree trunks have been seen here.

A very interesting feature of the quarry is a supply of natural gas, which has been tapped by simply boring to a moderate depth and inserting a pipe through which the gas rises, and is conveyed to the brickworks, where it is used for heating and lighting purposes. The supply is remarkably constant and only fails occasionally during periods of high barometric pressure. Mr. M. A. Odling, M.A., B Sc., F.G.S., has made an analysis of the gas, and found it to consist of 95% methane, and 5% of air.

List of Fossils.

The following list of fossils includes those which have been obtained and identified to date. It is necessarily very incomplete; fresh specimens are being constantly collected, and we hope to

publish an additional list at some future time. The letter R indicates that the species is of rare occurrence in that particular bed. Owing to the method of working the shale it is frequently impossible to say whether a particular specimen is from bed 11 or bed 13; it has therefore been thought desirable to make a special column for such cases. *Neuropteris heterophylla* is by far the most abundant fern in bed 4, while *Mariopteris muricata* is the predominant type in the higher beds.

Bed:—	4	6	11	11 or 13	13
Calamites Cisti, Brong.			X		
,, *undulatus*, Sternb.	X				
Sphenophyllum cuneifolium, Sternb. *sp.* ...				X	X
,, ,, *forma saxifragæfolium* Sternb.			X		
,, *sp.*					X
Sphenopteris trifoliolata, Artis *sp.*					X
,, *sp.*	R				
Neuropteris heterophylla, Brong.	X		R	R	
,, *Osmundæ*, Artis, *sp.*	X				
Mariopteris muricata, Schl. *sp.*			X	X	X
Alethopteris decurrens, Artis, *sp.*	R				
Lepidodendron simile, Kidston		X	X	X	X
,, *ophiurus*, Brong.		X		X	X
,, *aculiatum*, Sternb.			X		
,, *obovatum*, Sternb.				X	
,, *cf. ophiurus*, Brong.					
,, *sp.*	X	X			
Lepidophloios laricinus, Sternb.					
,, *cf. laricinus*, Sternb.	X				
Lepidostrobus, sp.		X	X	X	X
Lepidophyllum lanceolatum, L. & H. ...			X		X
Cyperites bicarinata, L. & H.					X
Stigmaria ficoides, Sternb. *sp.*	X				

Carbonicola aquilina
Anthracomya modiolaris } Bed No. 7.
Naiadites modiolaris

A single specimen of *Carbonicola aquilina* was found in Bed No. 4, in an ironstone nodule.

Cleat.

At the suggestion of Prof. P. F. Kendall (see article on "Cleat in Coal Seams," Geol. Mag., Feb., 1914), we have determined the direction of the Cleat in the various Coal Seams in the Quarry.

No. of Bed. (see Plate No. 2).	Cleat.	
1	N. 43° W.	
5	N. 46° W. (average of 3 readings)	all magnetic
10	N. 42° W. (,, 2 ,,)	
12	N. 41° W. (,, 2 ,,)	
14	N. 43° W.	

Prof. Kendall gives the cleat in the Haigh Moor Seam as N. 43° W.

Conclusion.

We desire to express our thanks to Dr. R. Kidston, F.R.S., for examining and naming the plants; to Dr. Wheelton Hind who has identified the mollusca; to Mr. F. E. Ellison, B.Sc., Mr. A Charlesworth, M.Sc., and Mr. H. Crowther, F.R.M.S., for the photographs; and to Messrs. Geo. Armitage & Sons who have granted every facility for work in their quarries, and who have also furnished us with useful information relating thereto.

PRESENTATION TO MR. E. HAWKESWORTH, AND MRS. HAWKESWORTH.

There was a very large attendance at the meeting on March 14, 1913, when a presentation was made to Mr. E. Hawkesworth, the present hon. secretary, in recognition of his completion of 25 years' service as an officer of the Association.

Letters or telegrams regretting inability to be present were read from Messrs. B. Holgate, F.G.S., C. T. Whitmell, M.A., B.Sc., and Godfrey Bingley, past presidents ; and W. Parsons, F.R.G.S., Principal of the City of Leeds Training College ; W. Cash, F.G.S., Halifax ; W. Thornber, and others.

The President, Mr. A. Gilligan, B.Sc., F.G.S., occupied the chair, and paid a warm tribute of praise to the services rendered to local geologists by both Mr. and Mrs. Hawkesworth. The present excellent position of their Association, he said, was owing in large measure to the untiring energy and zeal with which Mr. Hawkesworth had worked. He (the speaker), in common with all other members of the Association, knew that it had been a labour of love, but they also knew that he had brought an excellent and successful business experience to bear on the organisation. He joined at a time when it needed men of such calibre ; he had stuck to it through thick and thin, and had quite refused to be fossilised—(laughter)—and he was now possibly a better secretary than he ever had been before. (Applause).

Professor P. F. Kendall, M.Sc., F.G.S., said that since Mr. Hawkesworth took over the secretarial duties the Society had enjoyed a vastly increased prosperity. As a geologist he had enriched many public collections, notably the Museum of the Leeds Philosophical and Literary Society, as well as several national collections and those of the University. (Hear, hear). As a secretary he might term him " a benevolent despot." (Applause).

Messrs. W. Denison Roebuck, F.L.S. ; H. Crowther, F.R.M.S., curator of the Leeds Museum ; F. W. Branson, F.I.C., past president ; Councillor J. E. Bedford, F.G.S., past president ; and Professor G. R. Thompson, B.Sc., F.G.S., also added their tribute of praise to the secretary.

The Chairman then presented to Mr. Hawkesworth an oak roll-top desk, an attaché case and a handsome illuminated address. A tablet on the desk is inscribed as follows :—" Presented to Mr. Edwin Hawkesworth (along with a gold and pearl pendant to Mrs. Hawkesworth), by the members of the Leeds Geological Association in grateful recognition of his valuable services Member of the Council 1888–1890, Hon. Assistant Secretary 1890–1894, Member of the Council 1894–1903, President 1903–1905, Hon. Secretary 1905–1908, Hon. Secretary and Treasurer 1908–1913, Editor of the Association's " Transactions," vols. 13 to 16, March 14th, 1913."

Dr. D. Forsyth, M.A., D.Sc., then presented Mrs. Hawkesworth with a pearl, amyethst, and emerald pendant, and in doing so remarked that the great amount of time which Mr. Hawkesworth had devoted to their interests must have meant many sacrifices on the part of both him and his wife. Mrs. Hawkesworth had loaned her husband to the Association, and they were grateful. (Applause).

Mr. Hawkesworth, in acknowledging the presentation, said that this was an occasion which happened very rarely, and made it exceedingly difficult to find words to adequately express his feelings. When the intentions of the Association were intimated to him, they came as an enormous surprise, because he felt he had done nothing to merit such recognition. Twenty-five years was certainly a long period in the life of either a society or an individual. He had been blessed, or otherwise, by an extra amount of youthful precocity, perhaps not altogether commendable, and had started young, hence, after such a length of service he was not quite at " the sere and yellow leaf " stage. He hoped that for many years

to come the Association would still keep him on its list of officers, even if not as hon. secretary, which post he would probably have to relinquish before long. He sometimes thought that from his youth up some dire fate had sentenced him to a continuous round of work, but he preferred to think that a kind Providence had ordained that his life should be a round of pleasurable duty. During his connection with the Association he had seen many changes in its membership, but one of his most memorable rewards was the friendly intercourse with the members, many of them men of great scientific attainments, all of them of genial personality and kindly manner, always anxious to help forward the objects of the Association. Whilst it was gratifying to feel that his work met with the appreciation of his fellow members, he was more than delighted when it was stipulated that some mark of it should be shown to Mrs. Hawkesworth, whose encouragement in the work he had always had the advantage of. Words could not express his gratitude to the subscribers, whose appreciation was quite out of proportion to anything he had done for the Association. Their handsome gifts would be treasured by himself and his wife, and handed down to their children, with the hope that they, in their turn, would endeavour to do their duty, and take their share of the work, in whatever walk of life they might follow.

REPORTS OF EXCURSIONS.

BY. E. HAWKESWORTH.

WOODLESFORD, May 31st, 1911 (evening). The object of this excursion was to examine new sections in the alluvium of the Aire Valley, made in the course of constructing the works in connection with the Water Haigh Colliery, of Messrs. Hy. Briggs, Sons & Co., Ltd., who had kindly granted permission. The deposits are very variable in thickness, and irregular in occurrence, consisting principally of beds of clay, sand, and gravel.

A typical section, on the north side of the ground, showed :-

Top soil, and poor clay, with pebbles ..	3 feet
Clay	2 ,,
Gravel, with pebbles varying from 1 to 6 inches	½ ,,
Fine yellow sand	2 ,,
Gravel	1½ ,,
Fine clayey sand	1 ,,
Sand, with clay and loam bands	2½ ,,

Some of the sections showed two beds of clay, separated in some places by 3 or 4 feet of sand, in others by as much as 7 feet, whilst in others the intervening sand was absent. The sands vary in colour from black, due to much carbon and iron, through brown, to light buff, the grains being encrusted with hydrated oxide of iron. They consist of quartz, felspar, grit fragments, mica, ironstone grains, coal, and very micaceous Coal Measure shales. Mr. A. Gilligan, B.Sc., F.G.S., one of the leaders, (along with Mr. E. L. Hummel, B.Sc.), who has devoted special attention to the components of these deposits, reported that he had also found a few zircons and garnets in the sand, but only one certain grain of tourmaline. The quartz grains are angular, but examination proves the angles not to be due to fracture, but to new facets being developed. The sands are current bedded, the general

direction being E.S.E. There is no grading of the material, and the sand contains many stones, all of Coal Measure sandstones, gannister, or grit. The gravels are distributed very irregularly, often in pockets. They are made up of pebbles similar to the constituents of the sands, varying in size from quartz grains to six inch pebbles, the larger ones being usually well rounded. Chemical tests prove the presence of a large quantity of calcite. The clays are very finely laminated in the lower parts of the beds, and the upper unlaminated part is penetrated by rootlets. The laminæ run about 80—100 to the inch, and are of different colours, the dark bands being very fine grained, with some grains of angular quartz; the lighter bands containing more quartz, with much calcite. Some brown concretions found in the clay were found to be almost pure calcium carbonate.

In places these deposits were seen resting upon an uneven surface of Coal Measures, showing the original contour of the valley. These measures were much contorted, which, it was suggested, might be due to pressure caused by the passage of a glacier over them. There was considerable discussion as to the origin of the deposits, which appear to be deltaic, rather than river terrace. The clays certainly must have been deposited in very still water.

INGLETON—June 17th, 1911. By kind invitation of the Yorkshire Geological Society. The Association has paid many visits to this district of classical geological interest, but attention has been confined to the study of the Pre-Carboniferous and Carboniferous rocks. The object of this excursion was to examine the small patch of Permian rocks lying to the N.W. of Ingleton, a patch which has not received the careful study it deserves, for it opens up many interesting problems. The sections show two distinct types of breccia, which to those acquainted with the Magnesian Limestones of the Permian of the Leeds district, appeared somewhat strange. The Lower Breccia was seen in Winking Bank Lane, near West House, and a special search was made for

pebbles of Spirorbis Limestone, but none were found, though several had been recorded by earlier visitors. Many years ago, Mr. Binney pointed out the similarity of this, also a peculiar chert in the breccia, to beds occurring in the Ardwick series of Coal Measures, near Manchester, and, earlier in the day, some time had been spent by the party in endeavouring to find the Spirorbis Limestone in the Coal Measures exposed in the bed of the Greta, at Ingleton, which, in some respects, resemble the Ardwick measures, This was a possible source of origin of the limestone in the breccias. but the search was unsuccessful. A very good section of the Upper Breccia was seen in Mason Gill. Its appearance was quite different from the lower breccia, as were its contents, which were principally pebbles of Silurian slates, Carboniferous Limestone, with some Millstone Grit, in a matrix of sand, the grains of which were clearly wind-worn. The striking difference between these two deposits,—one containing little else but Coal Measure rocks,—the other containing none of these, but huge quantities of Lower Carboniferous and pre-Carboniferous rocks, leads to the inference that the denudation of the Ingleton fault-block was divided into two stages. In the first, the movement of the faults had exposed nothing below the Carboniferous Limestone, while, in the second the movement of the Dent fault had exposed the Silurians to denudation. The views of Professor P. F. Kendall, M.Sc., F.G.S., (who acted as leader of the excursion) on this important question are published in the Proceedings of the Geologists' Association, London, vol. 22, pt. 1, Binney's "Observations on the Permian Beds of the North-West of England" are published in Memoirs of Manchester Lit. and Phil. Society, vols. 12 and 13, new series, 1855, 1857.

ROUNDHAY PARK—June 20th, 1911 (evening). Leader, Mr. A. Gilligan, B.Sc., F.G.S. The quarry in the Millstone Grit, a little east of the entrance to the Gorge, was visited first, the beds here showing a good example of a step-fault, the bed of softer material

between the two beds of grit being very much crumpled. The contorted shales in the Gorge, the highest fossiliferous horizon of the Millstone Grit series, were examined, and many fossils of marine types were found, including *Goniatites*, *Anthracomya*, *Aviculopecten*, and some fish remains. In another quarry close by the beds of grit exhibited traces of faulting.

ROBIN HOOD QUARRIES—June 18th, 1912 (evening). A detailed account of the sections seen appears on page 31.

KNARESBOROUGH—June 22nd, 1912, leader, Mr. A. Gilligan, B.Sc., F.G.S. The classic section under the Castle Hill, and farther down the north bank of the Nidd, showing the Magnesian Limestone, laid unconformably on an undulating denuded surface of Millstone Grit, was examined. A visit was paid to the Town Lime Quarries (by kind permission of Mr. Atkinson), which show an extensive section in the Lower Magnesian Limestone. It is quite devoid of fossils, but contains numerous cavities, beautifully lined with crystals of dolomite. A pleasant walk by the river side brought the party to Grimbald Crag, an outlier of Magnesian Limestone resting on Millstone Grit. Many interesting physical features were noted in the valley, which for some distance is a characteristically U shaped glacial gorge. Heaps of gravel, which had slipped down from the summit of the south bank, were found to contain many pebbles of Carboniferous Limestone, cherts, grits, and sandstones.

LEEDS STEEL WORKS—July 18th, 1912 (evening). The main object of the excursion was to examine the ironstones used, which are chiefly from Northamptonshire, and North Lincolnshire, the latter—Lias, being very fossiliferous. The party was shown round the works, and had the opportunity of seeing in work all the processes necessary in making steel tram rails from iron ore.

ASKERN—October 12th, 1912, leader, Mr. H. Culpin (whose decease, a few weeks later, is deeply regretted by all local geologists).

The Sand Quarry was first visited, where Glacial Gravels, consisting almost entirely of fragments of Magnesian Limestone, were seen resting upon Triassic (Bunter) sand. The workings have exposed recently a face of Magnesian Limestone, faulted against this sand. Middle Permian Marls with bands of gypsum, were seen in the Brick Yard. Sections made in constructing sidings for the new colliery showed the Upper and Lower Magnesian Limestones faulted against each other. A considerable time was spent in examining the material obtained in the sinking of the colliery, special attention being paid to that from the marine band above the Barnsley Bed coal, from which large numbers of fossils were obtained, including a complete fish, and a crustacean, neither of which have yet been determined, *Goniatites*, *Orthoceras*, *Carbonicola*, *Lingula*, and many others.

ROUNDHAY—May 21st, 1913 (evening), leader, Professor P. F. Kendall, M.Sc., F.G.S. The excursion was termed by the leader as "a simple exercise in geological mapping," and those present had a valuable demonstration in reading at a glance the bolder geological features of the district, and by a more intimate examination to lay down the finer lines. Starting at Moortown the contrast was noted between the grasslands of the Coal Measures, and the arable land of the Millstone Grit. In Stonegate Road the party passed over the fault which forms the northern boundary of the Yorkshire coal-field, and in the neighbourhood of Shadwell Grange the lines of some smaller faults were traced by the nature of the surface, and the vegetation.

BURNSALL and district, June 7th, 1913 (Y.N.U.) Leader, A. Wilmore, D.Sc., F.G.S. The party met at Skipton station, and, during the journey from there to Rylstone the leader pointed out the most important geological features of the district. The anticline near the Haw Bank tunnel was clearly seen. The first duty on arrival at Rylstone was to examine sections in the Lower Carboniferous Limestone, that is the beds of Tournaisian age, which are fine-grained, dark coloured limestones, in striking con-

trast to the "Knoll" limestone seen later in the day. An old quarry near Hetton exposed these Tournaisian limestones, dipping north at about 65°, which yielded several characteristic fossils, including *Syringopora reticulata*, *Caninia cylindrica*, *Orthotetes crenistria*, and *Productus pustulosus*. Similar beds were seen in a quarry at Skelda Gate, showing signs of folding, and yielding similar fossils, with the addition of *Chonetes*. A large quarry at Winterburn showed large numbers of corals and other fossils as previously mentioned, also *Michelinia megastoma*. The party then walked back to a quarry on the railway side, east of Rylstone, in which were exposed extensive sections in the Upper Carboniferous Limestone (Viséan). Fossils were plentiful, amongst those obtained being *Zaphrentis amplexoides*, *Densiphyllum* sp., *Lophophyllum* sp., and other corals, *Orthoceras* sp., and a good specimen of *Prolecanites compressus*. Returning to Rylstone station, the party was reinforced considerably in numbers. The lower limestones were examined in Cracoe Gill, the beds being much disturbed. Fossiliferous beds of the upper limestone were seen higher up the Gill, and numerous brachiopods, corals, and polyzoa were collected. Close by were shales of the Pendleside series, with characteristic fossils. The famous "reef knoll" of Swinden, now almost dissected by the quarrying operations of Messrs. P. & W. Spencer, who had kindly given permission, was next visited. The old battle of the organic against the tectonic origin of these Craven knolls was fought over again, with the usual inconclusive result, the leader giving a very interesting review of the arguments put forth in favour of each theory. Proceeding into the beautiful valley of the Wharfe, at Linton, the party walked along the line of the Craven Fault, towards Burnsall, many evidences of the dislocation being seen, the folded beds of Loup Scar, as interetsing geologically as it is scenically beautiful, attracting special attention. From every point of view a most enjoyable and instructive day was spent, thanks to the splendid weather, and the intimate knowledge of the district so willingly placed at the disposal of the party by Dr. Wilmore.

THE LIBRARY.

The Books belonging to the Association are in the care of the Hon. Secretary, who is always glad to arrange for the loan of them to members, on suitable notice being given, and postage, etc., paid.

Besides a number of miscellaneous pamphlets, etc., and a few books, such as Tate and Blake's "Yorkshire Lias"; Lyell's "Principles of Geology"; Phillips' "Yorkshire Coast"; Mantell's "Pictorial Atlas of Fossils"; the following are received as published :—

"The Naturalist" (monthly).

"The Quarterly Journal of the Geological Society of London" (*presented by Mr. Arnold Lupton*).

"The Proceedings of the Geologists' Association" (London).

"The Proceedings of the Yorkshire Geological Society."

"The Transactions of the Yorkshire Naturalists' Union."

"The Transactions of the Liverpool Geological Society."

"The Transactions of the Leeds Naturalists' Club."

"The Transactions of the Leeds Astronomical Society."

"The Transactions of the Hull Geological Society."

"The Transactions of the Edinburgh Geological Society."

"The Annual Report of Progress of the Geological Survey."

"Journal of the Manchester Geographical Society."

"Memoirs of the Manchester Literary and Philosophical Society."

"British Association Reports."

"Records of the Australian Museum."

"United States Geological Survey—Bulletins, Professional Papers, and Monographs."

"Reports of the Smithsonian Institution."

List of Members at end of Session, 1912-13.

*Those who have contributed Papers or conducted Excursions are distinguished by an asterisk.**

Year of Election.

Honorary Members.

1886 *Horne, Wm., F.G.S., Leyburn.

1891 *Marr, J. E., D.Sc., F.R.S., F.G.S., Cambridge.

1874 *Miall, Prof. L. C., F.R.S., F.G.S., F.L.S., Letchworth.

1887 *Sollas, Prof. W. J., M.A., D.Sc., LL.D., F.R.S., F.G.S., Oxford.

1890 *Woodward, A. Smith, LL.D., F.R.S., F.L.S., F.G.S., British Museum, (Natural History), London.

1896 *Groom, Prof. T. T., M.A., D.Sc., The University, Birmingham.

1907 *Bond, J. W., Torre Road, Burmantofts, Leeds.

1902 *Thompson, Professor G. R., B.Sc., F.G.S.

Ordinary Members.

1904 Abbott, A., 2, Langdale Terrace, Headingley, Leeds.

1891 *Bailey, J. W., 2, St. Mark's Villas, Leeds.

1897 Bain, J., Post Office House, Leeds.

1904 Beahan, J. J., City Engineer's Office, Leeds.

1882 *Bedford, J. E., F.G.S., "Arncliffe," Shire Oak Road, Leeds. (*Past President*).

1889 *Bingley, Godfrey, "Thorniehurst," Shaw Lane, Leeds (*Past President*) (*Member of Council*).

1895 *Bees, W. J., B.Sc., 43, Ash Grove, Leeds.

1908 Booth, Peter, 232, Park Crescent, Frizinghall, Bradford.

1911 Bottomley, E. W., 12, Bellbrook Avenue, Harehills, Leeds.

1909 Bowen, David, 62, Cardigan Road, Leeds.

1883 *Branson, F. W., F.I.C., 14, Commercial Street, Leeds (*Past-President*).

1908 Branson, F. H., Myrtle Cottage, Talbot Road, Roundhay, Leeds.

1909 Broadbent, F. J., Croft House, Mirfield.

1904 *Burnet, Arthur, 52, Prospect Terrace, Hunslet, Leeds (*Member of Council*).

1908 Burgess, W. E., B.Sc., 17, Pawson Street, Morley.

1910 Champion, C. L., B.Sc., 31, Virginia Road, Leeds.

1906 *Cheetham, C. A., Nutting Grove, Farnley, Leeds.

1905 Charlesworth, A., M.Sc., 100, Bankside Street, Roundhay Road, Leeds (*Member of Council*).

1912 Cook, Edmund, Hollyshaw Lane, Whitkirk, Leeds.

1891 *Clough, S., 1, Ash Grove, Menston-in-Wharfedale.

1906 *Crowther, Hy., F.R.M.S., The Museum, Leeds.

1890 *Cuttriss, S. W., M.I.E.E., Richmond Mount, Leeds.

1908 Dixon, Wm., City Engineer's Office, Leeds.

1896 Dodgson, Aquila, South Lea, Kirkstall Lane, Leeds.

1896 *Dwerryhouse, A. R., D.Sc., F.G.S., Deraness, Deramore Park, Belfast (*Past President*).

1910 Ellison, Fred, Parnaby House, Rothwell Haigh, Leeds.

1905 Everett, J. H., B.Sc., 113, Cross Flatts Grove, Leeds. (*Member of Council*).

1912 Farrar, Jno. R., Mining Engineer, Ledstone, Castleford.

1910 Firth, Herbert G., 63, Headingley Mount, Leeds.

1911 Fisher, Greevz, 78, Chapel Allerton Terrace, Leeds.

1891 *Forsyth, David, M.A., D.Sc., 101, Caledonian Road, Leeds (*Past President*) (*Member of Council*).

1907 Foster, Hy., 48, Ridge Mount, Armley, Leeds.

1909 Gill, E., Fold Head, Mirfield.

1907 *Gilligan, A., B.Sc., F.G.S., "Craig Holme," Outwood Lane, Horsforth, Leeds (*President*).

1912 Glossop, Wm., Highfield, Hipperholme, Halifax.

1907 Grant, C. H., M.Sc., F.R.Met.S., 212, Burley Road, Leeds.

1907 Hart, Geo. A., City Sewerage Engineer, Leeds.

1886 *Hawkesworth, Edwin, "Sunnyside," Crossgates, Leeds (*Past President*), (*Hon. Secretary*).

1890 Heaton, Hy., "Cot Field," Roundhay, Leeds.

1908 Henzell, Chas. G., City Waterworks Engineer, Leeds.

1910 Hobley, Robt. A., B.Sc., Ashville Terrace, Farnley, Leeds.

1875 *Holgate, Benj., F.G.S., "The Briers," Roundhay, Leeds (*Past President*).

1906 *Hodges, Isaac, F.G.S., Woodlesford, near Leeds.

1905 Hornby, John, St. Jude's School, Hunslet, Leeds.

1907 *Hummel, Professor E. L., B.Sc., Mining Dept., The University, Leeds.

1886 Kay, Stanley R., High Mead, Wood Lane, Headingley, Leeds.

1891 *Kendall, Prof. P. F., M.Sc., F.G.S., Sandhill Lane, Moor Allerton, Leeds (*Past President*), (*Member of Council*).

1909 Kendall, Percy, B.Sc., Sandhill Lane, Moor Allerton, Leeds.

1906 Keighley, L., 105, Tempest Road, Beeston Hill, Leeds.

1908 Marsden, Oliver, 7, Regent Terrace, Hyde Park, Leeds.

1910 Milner, J. E., B.Sc., 10, Dorset Avenue, Harehills Lane, Leeds.

1889 Mitchell, F., 9, Upper Fountaine Street, Leeds.

1907 Murray, R., The Manor House, Barwick-in-Elmet, Leeds.

1911 Odling, M., M.A., B.Sc., F.G.S., Geological Dept., The University Leeds.

1895 *Parsons, W., F.R.G.S., Principal, City of Leeds Training College, Beckett's Park, Leeds (*Member of Council*).

1908 *Pickering, G. F., Woodcroft, Newlay Lane, Horsforth, Leeds.

1911 Pickering, Mrs. G. F., Woodcroft, Newlay Lane, Horsforth, Leeds.

1909 Pickles, H., B.A., B.Sc., 22, Winston Gardens, Headingley, Leeds.

1902 Price, A., B.Sc., 86, Blenheim Road, Barnsley.

1907 Price, J. W., North Terrace, Crossgates, Leeds.

1881 Roebuck, W. Denison, F.L.S., 259, Hyde Park Road, Leeds.

1887 *Rowley, Walter, F.S.A., F.G.S., Alder Hill, Meanwood, Leeds.

1904 Robinson, W. J., 54, Cardigan Lane, Leeds.

1906 Stephenson, H. L., 90, Tempest Road, Beeston Hill, Leeds.

1911 Swales, J. K., Deputy City Water Engineer, Leeds.

1906 Thornber, W., 68, Avenue Hill, Harehills, Leeds (*Member of Council*).

1911 Thomas, Ed., 41a, Cemetery Road, Beeston Hill, Leeds.

1908 Walker, Arthur, 1, Headingley Mount, Kirkstall Lane, Leeds.

1912 Walling, E., 20, Kelso Road, Leeds.

1908 Ward, Jas. E., Hanover Square, Leeds.

1897 *Whitmell, C. T., M.A., B.Sc., "Invermay," Hyde Park, Leeds, (*Past-President*). *Member of Council.*

1905 Whitmell, Mrs. C. T., "Invermay," Hyde Park, Leeds.

1906 *Wilson, G. V., B.Sc., H.M. Geological Survey, Edinburgh.

1909 Wills, Albert E., Denby Villas, Knowle Road, Mirfield.

Country Members.

1883 *Brownridge, Lieut. Colonel Chas., V.D., F.G.S., M.I.C.E., 21, Willow bank Road, Birkenhead (*Past President*).

1910 Burton, J. J., F.G.S., Rosecroft, Nunthorpe, Yorks.

1889 *Carter, W. Lower, M.A., F.G.S., "Bolbec," Bushey Grange Road, Watford.

1886 Crowther, J. A., Borough Engineer, Southampton.

1910 Crozel, G., Collonges-sur-Saone, France.

1907 Duchesne, H., B.Sc., Elstow School, Bedford.

1904 *Edwards, E. J., M.Sc., 19, Deri Road, Roath, Cardiff.

1908 Guy, Ernest, M.Sc., 16, Gloucester Street, Leamington Spa.

1910 King, Wm. N., M.Sc., 5, Allergate Terrace, Durham.

1906 *Johns, Cosmo, M.I.M.E., F.G.S., Burngrove, Pitsmoor Road, Sheffield.

1908 Jukes-Browne, A. J., B.A., F.G.S., Westleigh, Torquay.

1911 Hartshorn, John, Leyburn, Yorks.

1911 Milton, J. H., F.G.S., Harrison House, Crosby, Liverpool.

1903 Nettleton, Stanley, Johannesburg, South Africa.

1909 Parsons, Ernest, M.Sc., F.G.S., Gwalior, India.

1889 Wilkinson, Jno. J., Burnside, Skipton.

Associates.

1912 Atkinson, Miss E. M., Haigh Villa, Stourton, Leeds.

1911 Crosfill, Jno., B.Sc., Gledhow Wood Avenue, Leeds.

1912 Dry, —, The University, Leeds.

1910 Fearnley, L. W. K., B.Sc., 2 Dial Villas, Woodhouse Moor, Leeds.

1912 Hawkesworth, Arthur G., Sunnyside, Cross Gates, Leeds.

1912 Jagger, Miss M. E., 46, Mount Preston, Leeds.

1908 Kay, Stanley B., High Mead, Wood Lane, Headingley, Leeds.

1912 Kirk, Leonard B., B.A., Cemetery Lodge, Wortley, Leeds.

1912 McDiarmid, D., 17, Hessle Place, Leeds.

1910 Mawson, F., Ashburn Villas, Featherstone.

1912 Mountain, J. W., 18, St. Luke's Crescent, Beeston Hill, Leeds.

1912 Morgans, Brynmor, B.Sc., Mining Dept., The University, Leeds.

1911 Parsons, Geo., 13, Colville Terrace, Leeds.

1911 Rhodes, Arthur, 1, Cross Street, Morley.

1912 Versey, H. C., 19, Lucas St., Hyde Park, Leeds.

1911 Walbank, W. S., B.Sc., 1, Roundhay Grove, Leeds.

1912 Wynne-Edwards, R. M., 67, Clarendon Road, Leeds.

Fortieth Session, 1913-14.

Officers:

President: A. CHARLESWORTH, M.Sc.

Vice-President: A. GILLIGAN, B.Sc., F.G.S.

Hon. Secretary and Treasurer: E. HAWKESWORTH, Sunnyside, Cross Gates, Leeds.

Members of the Council:—

GODFREY BINGLEY.
F. W. BRANSON, F.I.C., F.C.S.
ARTHUR BURNET.
C. A. CHEETHAM.
J. H. EVERETT, B.Sc.
D. FORSYTH, M.A., D.Sc.
Professor P. F. KENDALL, M.Sc., F.G.S.
W. PARSONS, F.R.G.S.
G. F. PICKERING.
W. THORNBER.
C. T. WHITMELL, M.A., B.Sc., F.R.A.S.

Sale of Back Parts of the Transactions.

The Transactions of the Association contain a store of valuable geological information. Most of the subjects are dealt with at length, and the reports of excursions will be very useful to members visiting the localities described. *Part* 14 *contains a classified index of parts* 1 *to* 14. Parts 1 and 10 are now out of print, and the stock of some of the earlier ones is very limited.

Parts 2 to 16, except part 10, containing over 700 pages—to members and associates, 10/-; to non-members, 14/-; postage 6d. extra.

Separate parts for those desirous of completing their set: 4, 11, 12—6d. each to members and associates; 9d. each to non-members.

3, 5, 6, 7, 8, 9—9d. each to members and associates; 1/- each to non-members.

13—1/-	to members and associates;			1/6	to non-members.		
14—2/-	,,	,,	,,	2/6	,,	,,	,,
15—1/6	,,	,,	,,	2/-	,,	,,	,,
16—1/6	,,	,,	,,	2/-	,,	,,	,,

Very few copies of part 2 are left, and will only be supplied with full sets.

POSTAGE EXTRA.

Leeds Geological Association.

THE OBJECT OF THIS ASSOCIATION is to promote the study of Geology by means of field excursions, exhibition of specimens, reading of papers, and discussions.

MEETINGS are held on the **third Friday in each month** (except when otherwise stated), from October to May, in the **Geological Department of the University of Leeds (entrance 22, De Grey Road)**, at **7.30 p.m.**

EXCURSIONS are made frequently to places of Geological interest.

The Association is affiliated with the **YORKSHIRE NATURALISTS' UNION**, which constitutes each member an Associate of that Union, and, as such, entitled to attend all its Meetings and Excursions.

A volume of **TRANSACTIONS** is published occasionally, and issued free to Members and Associates.

TERMS OF MEMBERSHIP.

ORDINARY MEMBERS' Subscription, **5/-** per annum.

COUNTRY MEMBERS (residing 20 miles or more from Leeds), Subscription **2/6** per annum.

ASSOCIATES—Assistant Teachers in the Schools of the City, Students in attendance at Geological Classes, and others as the Council may determine, may become Associates, Subscription **2/6** per annum.

Country Members and Associates receive the Transactions as published, but do not receive separate notification of each Meeting and Excursion.

All Subscriptions are due in advance on JULY 1st in each year.

Members are invited to bring specimens for exhibition at any of the Meetings, or to report any matter of Geological interest which may come within their cognisance.

Members may introduce their friends (ladies and gentlemen) at the Meetings and Excursions.

Members are requested to at once notify the Hon. Secretary of any change of address.

Hon. Secretary and Treasurer—
E. Hawkesworth, Sunnyside, Cross Gates, Leeds.

CONTENTS.

Annual Report, 1911–12 ... ...

Financial Statement, 1911–12 ... ...

Some Petrological Characteristics of Dunsdale—[illegible]

The Association of the Lias—L. Thompson ... ...

Evidence of Climatic Changes in Geological Times—[illegible]

Annual Report, 1912–13 ... ...

Financial Statement, 1912–13 ... ...

Notes on Sections in Robin Hood Quarries (with 8 plates)
Hunt and Everett ... ...

Excursion to the Hon. Secretary ... ...

Report of Excursion to Woodplumpton ... ...

" " Ingleton ... ...

" " Hornsby Park ... ...

" " Robin Hood Quarries ...

" " Knaresborough ... ...

" " Lewis Steel Works ... ...

" " Askern ... ...

" " Rosmadley ...

" " Burnsall and district ... ...

The Library ... ...

List of Members ... ...

Officers for 1913–14 ... ...

Price List of back parts of Transactions ...

Errata of Membership, etc. ... ... [illegible]

Science Library
QE
1
.L48
v.4
pt.18

THE TRANSACTIONS OF THE LEEDS GEOLOGICAL ASSOCIATION

(Founded 1874).

PART XVIII.

1913-14	1916-17
1914-15	1917-18
1915-16	1918-19

1919-20

Price 5/-

Members may purchase extra copies at 4/- each, postage extra.

JOWETT & SOWRY LTD., Printers, Leeds.

UNIVERSITY OF MICHIGAN LIBRARIES

THE

TRANSACTIONS

OF THE

LEEDS GEOLOGICAL ASSOCIATION

(Founded 1874).

PART XVIII.

1913-14	1916-17
1914-15	1917-18
1915-16	1918-19

1919-20

Price 5/-

Members may purchase extra copies at 4/- each, postage extra.

Science Library
QE
1
.L42
v.4
c.1

PREFACE.

Owing to the accumulation of material for this Volume of Transactions, and the great increase in printing charges since the last Volume was issued, it has been deemed necessary to curtail the subject matter wherever possible. It was felt that this could be done more particularly in the case of the Annual Reports, by quoting extracts from them instead of printing them in full as has been the custom for so many years. In making these extracts the guiding principle has been to select them so that the sum total produced should present a history of the Association during the period covered (1913-1920) without giving any unnecessary repetition.

As in many previous volumes too, only such papers as are of local interest, or which are the result of original research, are included ; and where possible these are only abstracts.

J. H. EVERETT,
D. FORSYTH,
G. F. PICKERING,
H. C. VERSEY,
Editorial Sub-Committee.

November, 1921.

CONTENTS.

	PAGE.
Extracts from Annual Report, 1913-14	5
Creep—Preston	7
Excursions, 1914—Horsforth, Knostrop	9
Extracts from Annual Report, 1914-15	10
Excursions, 1915—Middleton Colliery, Bardsey..	11
Extracts from Annual Report, 1915-16	13
Borehole at Meanwood (*plates*)—Gilligan	15
Sections exposed during Leeds Infirmary Extensions (*plates*)—Gilligan and Odling	17
Excursions, 1916—Otley, Bradford (and Saltaire)	19
Extracts from Annual Report, 1916-17	20
Excursions, 1917—Rawdon, Elland Road Quarries	21
Extracts from Annual Report, 1917-18	22
Peat Problems—Miss E. D. Whitaker	23
Annual Report, 1918-19	28
Extracts from Annual Report, 1919-20	30
Financial Statement, 1920	32
Notes on some Sections in Elland Road (*plates*)—Everett and Pickering	33
Excursions, 1920—Clayton Wood (Horsforth), Castleford to Pontefract, Robin Hood, Ackton Hall Colliery, Marsden, Seven Arches ..	36
Library	38
List of Members	40
List of Presidents	43
"In Memoriam"	43
Terms of Membership, etc.	*Inside of Cover*

EXTRACTS from ANNUAL REPORT, 1913-14.

Nine evening meetings have been held as follows :—

1913.

Oct. 17—PRESIDENTIAL ADDRESS : A. CHARLESWORTH, M.Sc. " A Tertiary Volcano in Arran " (*lantern slides and specimens*).

EXHIBITS.

By THE STAFF OF THE GEOLOGICAL DEPARTMENT OF THE UNIVERSITY. Latest Maps and Memoirs, Microscope slides, rock specimens and fossils.

By Prof. P. F. KENDALL, M.Sc., F.G.S. : A Model of the Whitby District.

By Mr. A. GILLIGAN, B.Sc., F.G.S. : Yorkshire Rocks with Microscope Sections.

By Mr. M. ODLING, M.A., B.Sc., F.G.S. : Model of an Artesian Well at Oswaldkirk.

By Mr. H. L. STEPHENSON : Fossil Fish Teeth from Safaya, Upper Egypt.

By Mr. J. W. SUTCLIFFE : Specimens of Volcanic Rocks from East Fife.

Nov. 21—Mr. S. W. CUTTRISS, M.I.E.E. : " Prospecting for Gold in the Urals " (*lantern slides, specimens, maps*).

Dec. 12—Prof. P. F. KENDALL, M.Sc., F.G.S. : " The Deposition of Sand and Mud " (*specimens and experiments*).

1914.

Jan. 16—Mr. H. PRESTON, F.G.S. : " Creep " (*specimens and lantern slides*).

Feb. 6—Mr. A. BURNET : " Lithological and Microscopical Aspects of the Yorkshire Chalk " (*lantern slides, microscope slides, specimens*).

Feb. 28—Mr. M. ODLING, M.A., B.Sc., F.G.S. : " Some Rock Builders in Mesozoic Times " (*illustrated by a large collection of lantern and microscope slides*).

Mar. 25—Mr. A. GILLIGAN, B.Sc., F.G.S. ; " Meteorites " (*specimens, lantern slides and microscope slides*).

Apr. 3—Mr. J. J. BURTON, F.G.S. : " Coast Erosion " (*lantern slides*).

May 1—ANNUAL MEETING. Election of Officers, etc. Mr. A. GILLIGAN, B.Sc., F.G.S. read a short paper entitled: "A Short Holiday in the Isle of Mull."

Mr. C. A. CHEETHAM showed colour photographs to illustrate "Some Plant Geologists."

Mr. E. HAWKESWORTH exhibited some Drawings of various Sections in Yorkshire.

Mr. G. F. PICKERING exhibited some Silurian Rocks from Shropshire.

On November 17th a large number of members of the Association attended a lecture by Mr. Griffith Taylor, B.A., B.Sc., B.E., F.G.S. (Geologist of the Western Party on the Recent British Antarctic Expedition) on "Science and Sledging near the South Pole," by invitation of the Leeds Naturalists' Club and Scientific Association. On January 13th, by invitation of Professor P. F. Kendall, M.Sc., F.G.S., a large number of members attended a lecture given before the Leeds Philosophical and Literary Society by Lieut.-Colonel E. Kitson Clark, M.A., F.S.A., on "Prehistoric Yorkshire."

MEMBERSHIP.—During the Session 8 new members and 8 Associates have joined the Association. Mr. Benjamin Holgate, F.G.S., who joined the Association in 1875 shortly after its formation, and who for very many years took a leading part in its work, has been elected an Honorary Life Member. The Association has lost by death the last of its original members, in the person of Mr. H. Pocklington. Five members have resigned, and 11 associates have either resigned or been taken from the list on leaving the district.

The membership roll now stands as follows :—

Honorary Life Members	9
Ordinary Members	72
Country Members	17
Associates	25

a total of 123 as against 125 a year ago

CREEP.

Abstract of a Paper read by HENRY PRESTON, F.G.S. *on 16th January,* 1914.

Creep may be defined as the slow movements in rocks caused by the removal or addition of pressure. The examples of this described in this paper, are taken from the writer's own observations made during the carrying out of Engineering works in connection with water supply.

The close and interesting connection between Engineering and Geology is shown particularly, in the making of large dams in reservoir construction. The long and deep trenches that have to be excavated across a valley afford instructive geological sections, which may explain various episodes in the geological history of the valley which otherwise would remain unknown. Perhaps the most interesting revelation that such a section may give is of the action of lateral and regional pressure on the rocks lying immediately beneath the valley. The super-incumbent weight has been removed by the denudation of the valley, and creep, brought about by the weight of the hills on either side, may cause uplift in the centre of the valley, often accompanied by much wrinkling and puckering. A study of such sections shows that in the most simple cases, even where the strata are uniform in dip over a large area, it is not wise to assume a simple inclination of such strata when a river flows through the area.*

LIMESTONE FISSURES.

Excellent opportunities for observing the phenomena of creep are afforded by the so-called Cliff of Lincolnshire, *i.e.*, the escarpment of the Lincolnshire Limestone, which runs in a southerly direction from the Humber to Grantham where it bends round to the S.W., leaving a large plateau of limestone which is dissected by the east-flowing tributaries of the Witham. The outliers thus formed, resting as they do on a gently dipping surface of impervious Upper Liassic clay tend to creep gradually towards the East, thus producing large fissures the trend of which is almost parallel with the course of the River Witham.†

* See "Permanency of Overflow Springs." *Trans. Assoc. Water Eng.*, vol. XV.
† See "Geology South of Grantham." *Naturalist*, Aug., 1898.

Creep in Coombe Rock.

An excavation was made sometime ago at Eastbourne, during building operations and exposed a section showing Chalk Marl in which are various interesting solution pockets or pipes filled with Coombe Rock and Flints. A most interesting part of the section was a band, 1 foot in thickness, consisting of chalk rubble containing vast numbers of Chalk pebbles from the size of a pea upwards. The band seemed to show a clear stratification which the writer at first attributed to water action. Subsequent consideration, however, has caused him to look upon this band as due to a gradual creep of the surface and sub-surface soils on the chalk rubble, and the chalk fragments have been ground into pebbles by the creeping motion, the apparent stratification being the plane along which the chief motion has taken place.

The writer has noticed a similar action taking place in the Chalky Boulder Clay of Lincolnshire. In the north of the county, the contained lumps of chalk are often quite angular ; in the middle and south of the county these angular pieces have been either reduced in size or lost altogether ; but generally, those that are left are rounded, pebble-like, and often well scratched, whilst the clay matrix has become very limy in character owing to the grinding of these chalk fragments by the creeping Boulder Clay.

Creep of Brow of Escarpment.

When an escarpment of comparatively soft rocks exists, we may expect some strange phenomena in the strata along the ridge and on the top of the escarpment. The pressure of the superincumbent rocks will, at times, force the breast of the escarpment forward, and the overlying rocks will be let down. This may be not only in a direction opposite to their normal dip (as though the strata were dipping say W. instead of E.), but a series of step faults may be found in the overlying strata. This the writer has observed on several occasions.†

The writer has described other interesting examples of creep from the clayballs in the Bunter sandstone of Notts.*

† *Trans. Linc. Nat. Union*, 1913, p. 108.
† *Proc. Geol. Assoc.*, vol. XXI., 1909.
* See *Naturalist*, March, 1914.

REPORTS OF EXCURSIONS.

HORSFORTH.—May 6th, 1914 (evening). Leader, Mr. A. Gilligan, B.Sc., F.G.S. The object of the excursion was to examine an exceptionally fine section of the junction between the Millstone Grit and the Coal Measures exposed in Messrs. Whitaker's Quarries.

KNOSTROP.—May 25th (evening). Leader, Mr. G. A. Hart, M.I.C.E. After examining, in the Drawing Office, various coloured sections showing the strata exposed in the new excavations, the party proceeded to the detritus tanks where alluvial sands were seen resting on slightly crumpled Coal Measures, the folding of which was due to two faults. One of these faults was traced. Many fossil plants were seen in the sandstone which gives off numerous springs of water rich in magnesium salts.

EXTRACTS from ANNUAL REPORT, 1914-15.

Seven ordinary monthly meetings have been held as follows :—

1914.

Oct. 16—PRESIDENTIAL ADDRESS. A. CHARLESWORTH, M.Sc. : "Among the Coolin Hills" (*lantern slides and specimens*).

EXHIBITS.

By Mr. A. GILLIGAN, B.Sc., F.G.S. : Deerhorn picks and their markings from Grimes Graves, Brandon.

By Mr. M. ODLING, M.A., B.Sc., F.G.S. : Drawings and photographs of rock sections and fossils.

Nov. 20—Professor E. L. HUMMEL, B.Sc., M.E. : "Gold Mining on the Rand" (*specimens, maps, diagrams and lantern slides*).

Dec. 18—Mr. M. ODLING, M.A., B.Sc., F.G.S. : "The Significance of Fossils in the Interpretation of Geological History, with some limitations in zoning methods."

1915.

Jan. 15—Professor P. F. KENDALL, M.Sc., F.G.S. : "The Anthracite Problem" (*diagrams, specimens*).

Feb. 18—Mr. G. A. GERMAN, M.Sc. : "The Rivers of the Midlands" (*maps, diagrams and lantern slides*).

Mar. 19—Mr. T. SHEPPARD, M.Sc., F.G.S., F.R.G.S., F.S.A. : "Lost Towns of East Yorkshire" (*lantern slides*).

May 7—ANNUAL MEETING. Report, Balance Sheet, Election of Officers, etc. Mr. A. GILLIGAN, B.Sc., F.G.S., read a short paper on : "Some interesting Problems in Bowland."

Owing to the sudden illness of the reader of the paper and the short time making it impracticable to make other arrangements, the April meeting had to be cancelled.

On October 13th, a number of the members of the Association, by invitation of the Leeds Photographic Society, attended a lecture before that Society by Mr. L. F. Taylor on "Dr. Tempest Anderson's Last Journey."

On February 16th, the Association arranged, jointly with the Leeds Philosophical and Literary Society, a lecture by Mr. Raymond E. Priestley, F.G.S. (Geologist with Northern Party, Captain

Scott's last Expedition, 1913), on "With Captain Scott in the Antarctic." This gave the Association the opportunity of extending invitations to attend, to the Leeds Photographic Society, and the Leeds Naturalists' Club, thus returning a compliment paid to this Association on several occasions when its members have received invitations to attend lectures to those Societies. The Lecture was in every way a great success.

MEMBERSHIP.—During the Session two ordinary members, one country member and six associates have joined the Association. Your Council deeply regrets to record the death of Mr. Benjamin Holgate, F.G.S., who a year ago was elected an Honorary Life Member. He had been a member since 1875, was President, and for a great number of years took a leading part in the work of the Association, conducting excursions, reading papers, many of which are published in the Transactions, and in many ways encouraging the study of Geology in the district. Mr. A. J. Jukes-Browne, B.A., F.G.S., a country member, has passed away during the Session. It is gratifying to note that Mr. J. R. Farrar, a member, Mr. H. Duchesne, B.Sc., a country member, and Mr. Wynne-Edwards, an associate, are serving with His Majesty's Forces. The membership roll now stands as follows :—

Honorary Life Members	8
Ordinary Members	68
Country Members	16
Associates	27

a total of 119 as against 123 a year ago. The gradual falling off in the number of ordinary members should receive attention when times become more normal.

REPORTS OF EXCURSIONS.

MIDDLETON COLLIERY.—June 16th, 1915 (evening). By the kind invitation of Marshall Nicholson, Esq. (The Middleton Estate and Colliery Co. Ltd). After inspecting sections and plans in the Drawing Office, a quarry was visited which showed the Brown Metal Coal Seam and its accompanying measures dipping in a southerly direction. A little to the south of here the same coal

seam was being worked at a depth of 35 yards. Another section showed the Flockton Coal, 2½ feet thick, and above it a band of shale crowded with Anthracosia. The party then split into three sections, one to see the machinery and the colliery (Broom Pit, No. 2 was descended), another to see the coke-ovens, by-product plant, chemical works and laboratories, and the third to see the brickworks.

BARDSEY.—July 8th (evening). Leader, Mr. A. Gilligan, B.Sc., F.G.S. A disused quarry near Bardsey was first visited, showing beds of grit and shale, reddish brown in colour, belonging to the Middle Grits of the Millstone Grit Series. At the north end of East Keswick village a quarry of Lower Magnesian Limestone was examined and yielded several Schizodus. Along the Wetherby-Harewood road, two quarries, one in Millstone Grit, the other in Magnesian Limestone were visited, and as they occur at the same altitude, and as the beds are approximately horizontal, the evidence for a fault between them seemed very strong. The latter quarry contains a band yielding abundant fossil mollusca, mostly indeterminate, but many specimens of Schizodus and Bakewellia were found.

EXTRACTS from ANNUAL REPORT, 1915-16.

Eight evening meetings have been held as follows :—

1915.

Oct. 15—PRESIDENTIAL ADDRESS. J. H. EVERETT, B.Sc. : "Facts and speculations regarding the Antilles and the Carribbean Sea" (*lantern slides and diagrams*).

Mr. A. GILLIGAN, B.Sc., F.G.S. : "Notes on a Boring at Meanwood" (*specimens*).

EXHIBITS.

By Mr. A. GILLIGAN, B.Sc., F.G.S. : Slides showing moving inclusions in Quartz from the Millstone Grit.

By THE STAFF OF THE GEOLOGICAL DEPARTMENT OF THE UNIVERSITY : Microscope Slides of Siliceous Rocks, Photomicrographs of rock sections.

By Mr. C. T. WHITMELL, M.A., B.Sc., F.R.A.S. : Carboniferous Limestone and Chert from Lanshaw Delves (Ilkley).

Nov. 19—Professor P. F. KENDALL, M.Sc., F.G.S. : "The Retreat of the Ice Sheets in Britain" (*lantern slides, maps and diagrams*).

1916.

Jan. 21—Mr. M. ODLING, M.A., B.Sc., F.G.S. : "Some extinct Monsters" (*specimens and slides*).

Feb. 18—Mr. H. C. VERSEY, M.Sc. ; "Some new Aspects of Permian Geology" (*lantern slides, specimens and microscope slides*).

Mar. 17—Mr. A. GILLIGAN, B.Sc., F.G.S. : "Mineral Veins with special reference to the North of England" (*specimens and lantern slides*).

Mr. M. ODLING, M.A., B.Sc., F.G.S. : "Preliminary description of some Excavations at the Leeds Infirmary."

Apr. 7—Mr. G. F. PICKERING : "Some Difficulties of an Amateur Geologist."

May 5—ANNUAL MEETING. Report, Balance Sheet, Election of Officers, etc.

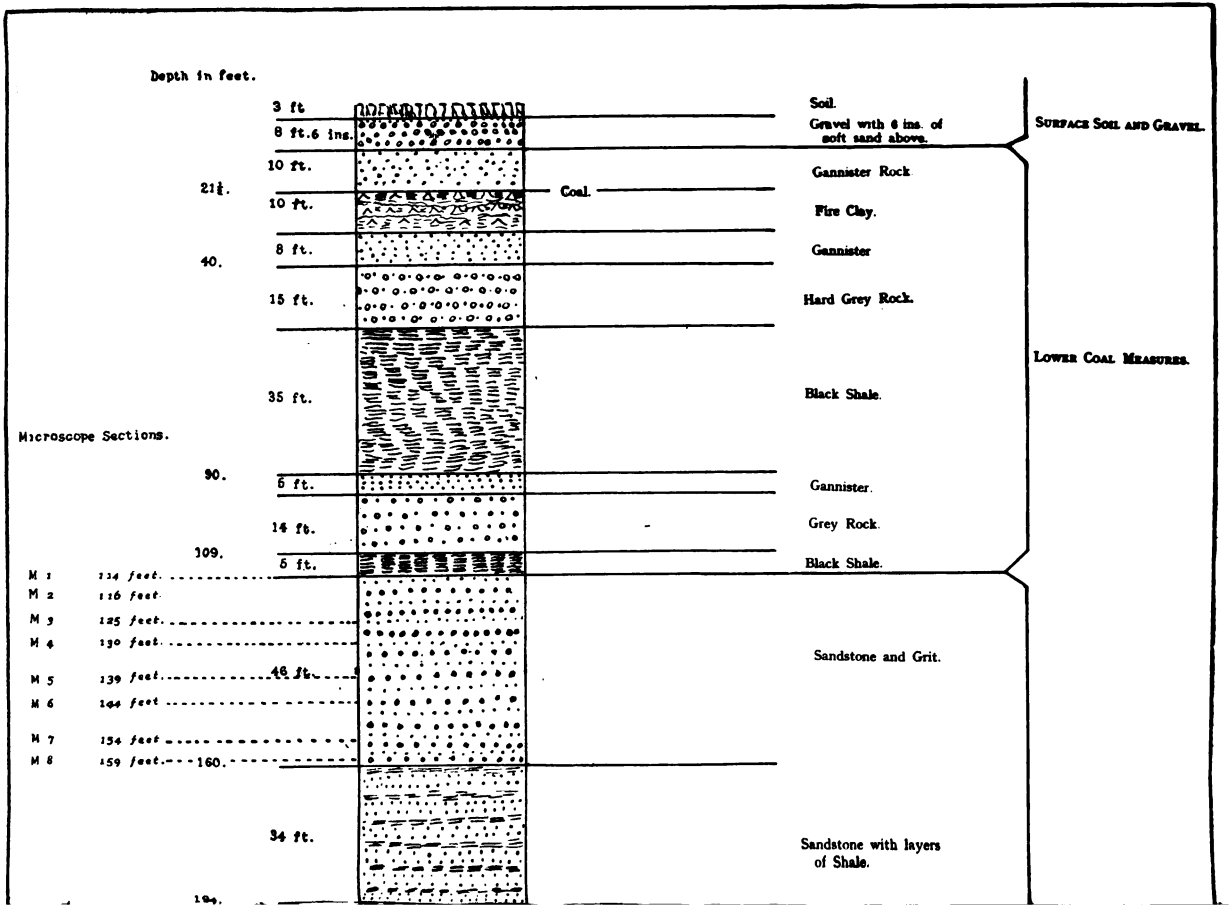
Mr. A. GILLIGAN, B.Sc., F.G.S., exhibited and described lantern slides from the Bingley Collection showing N.W. Yorkshire and the Lake District.

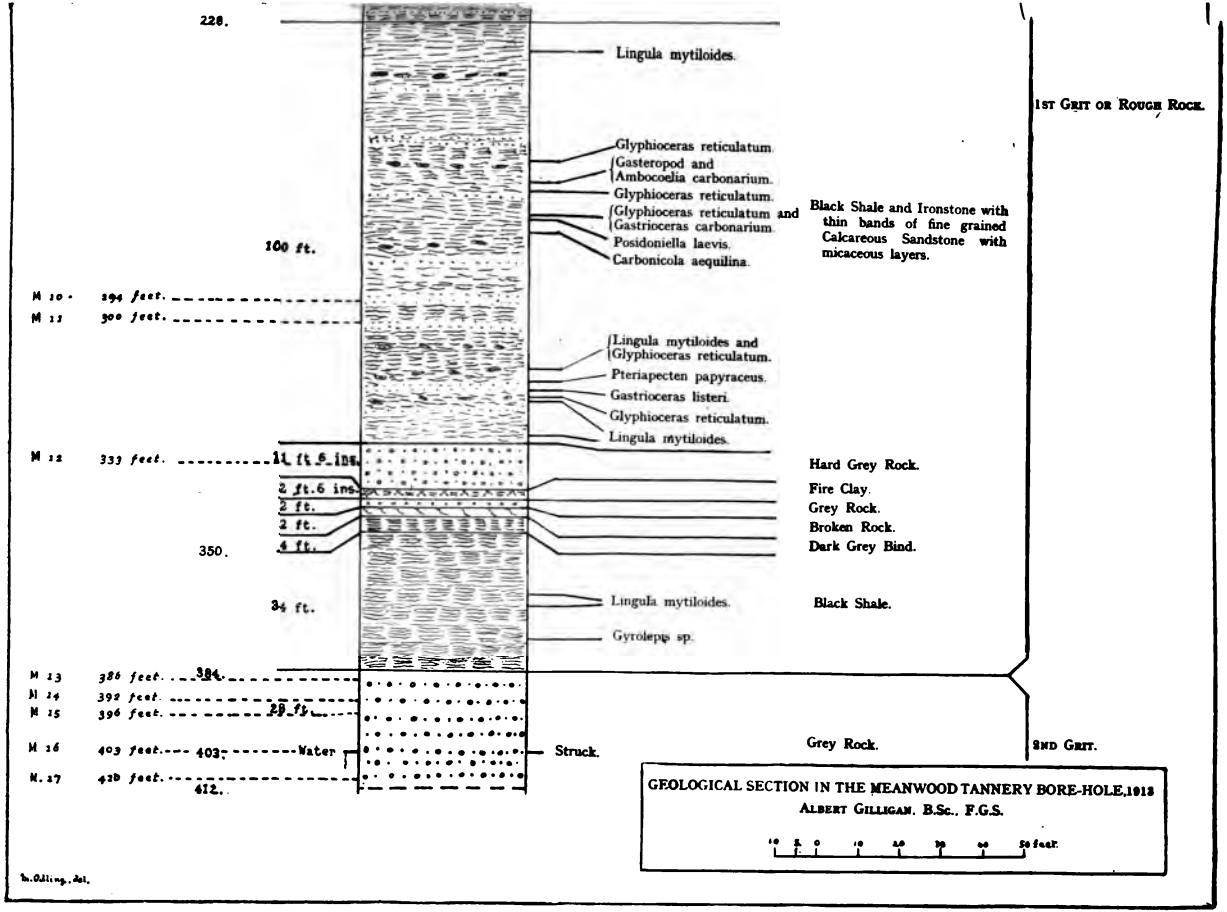
Mr. M. ODLING, M.A., B.Sc., F.G.S., described the excavations at the Leeds Infirmary.

On February 15th, a large number of our members attended a lecture before the Leeds Philosophical and Literary Society by Prof. G. Elliot Smith, M.A., M.D., F.R.S. on "The Piltdown Skull."

LIBRARY.—The publications of various societies and institutions have been received as usual, and Mr. Arnold Lupton continues his valuable gift of the Quarterly Journal of the Geological Society. When times become more normal, the question of making the Library more accessible to the members will have to be seriously considered, but in the meantime, the Honorary Secretary is always glad to place the books at the disposal of members.

It is gratifying to note that so far as can be ascertained, seven members and three associates are serving in H.M. Forces, and by the resolution of the Council they are retained on the list of members.


Depth in feet.
3 ft
8 ft.6 ins.
10 ft.
21½.
10 ft.
8 ft.
40.
15 ft.
35 ft.
90.
5 ft.
14 ft.
109.
5 ft.
46 ft.
160.
34 ft.
Coal.
Soil.
Gravel with 6 ins. of soft sand above.
Gannister Rock
Fire Clay.
Gannister
Hard Grey Rock.
Black Shale.
Gannister.
Grey Rock.
Black Shale.
Sandstone and Grit.
Sandstone with layers of Shale.
Surface Soil and Gravel.
Lower Coal Measures.
Microscope Sections.
M 1 114 feet.
M 2 116 feet.
M 3 125 feet.
M 4 130 feet.
M 5 139 feet.
M 6 144 feet
M 7 154 feet
M 8 159 feet.



Trans. Leeds Geol. Assoc. Part XVIII. Plate 1.

A BOREHOLE FOR WATER AT MEANWOOD, LEEDS.

By ALBERT GILLIGAN, D.Sc., B.Sc., F.G.S.

The borehole is situated close to Meanwood Beck, the ground surface being at a height of 175 ft. above O.D. and was put down in the year 1913, for the purpose of supplying water to the tannery of Messrs. Robert Jowitt and Sons, Ltd., of Leeds and Bradford. The great west to east fault which bounds the Yorkshire Coalfield on the north lies about half a mile north of the site.

The fault has a downthrow to the south and throws Coal Measures on the south side against Rough Rock on the north. The amount of throw is variable, increasing from west to east and being about 150 ft. where cut by Meanwood Beck. This is in agreement with the strata passed through in the boring. The fault cannot be watertight as it is quite clear that the water falling on the large grit area to the north finds its way across the fault to the south. This is easily explained by the juxtaposition of sandstone or grit beds, on either side of the fault. As will be seen from the Section, the borehole passed through the lower coal measures to a depth of 114 ft., and then encountered the Rough Rock which was 46 ft. in thickness and of the usual coarse type seen in the neighbouring quarries in Meanwood Woods.

Below this are the flagstones, 34 ft. in thickness, which pass downward into 34 ft. of shales with thin sandstones, and then follows 100 ft. of black shale with thin bands of ironstone and very fine grained calcareous sandstones.

The so called second grit was pierced at a depth of 384 ft., and at 403 ft. water rose to the top of the borehole and overflowed. Boring was continued to a depth of 412 ft., when the yield was found to be sufficient for the purposes required.

The borehole is piped to a depth of 380 ft. and the engineer of the works, C. J. Hunt, Esq., informs the author that at the present time (September, 1921), the water level stands between 10 and 20 ft. from the surface and the yield is 8,000 gallons per hour, though full tests with continuous pumping have not been made for some time.

The water as is usual with water from the Millstone Grit is very soft. At the time when the borehole was being put down the author was conducting researches into the mineralogical constitution of the Millstone Grit Series, and took the opportunity of examining the core and obtaining specimens of all the beds.

A full account of the results of these researches has now been published* and it will suffice to say that as had been found previously in the grit beds from boreholes at Bradford and elsewhere there was here evidence of the greater freshness of the felspars with increasing depth.

The microscope sections given herewith, plate 2, show some of the fresh felspars. The 100 ft. bed of shale is interesting on account of the presence throughout its whole thickness of marine fossils. The fossils were identified by the late Dr. Wheelton Hind, whose researches on the marine bands in the Millstone Grit and Coal Measures made him the first authority on the subject.

One interesting point in connection with the occurrence of these fossils is the intercalation of a Carbonicola bed between two marine bands.

From an examination of the marine shales in the Millstone Grit Series in the neighbourhood there can be no doubt that the bed here represented is to be correlated with that exposed in The Gorge at Roundhay Park which yields a similar fauna and represents the latest marine episode associated with the deposition of the Millstone Grit Series.

DESCRIPTION OF PLATE 2.

Fig. 1. M1. Rough Rock from borehole at a depth of 114 feet, Meanwood, Leeds.

Crossed nicols, X about 20 diams.

In the centre is shewn fresh microcline, the characteristic felspar of the whole Millstone Grit Series. Pebbles of this felspar are occasionally found an inch in diameter and shewing brilliant cleavage faces.

Many grains of quartzite can also be seen. The quartz grains contain inclusions and show strain shadows characteristic of rocks which have suffered mechanical deformation and the argument is that such quartz grains have been derived from gneisses and schists. Muscovite and biotite are also present.

The matrix is chiefly calcite.

Large garnets seen in the hand specimen.

Fig. 2. M3. Rough Rock from borehole at a depth of 125 feet, Meanwood, Leeds.

Crossed nicols, X about 20 diams.

Very little fresh plagioclase felspar (in this case oligoclase) is present in the Millstone Grit. This is one of the best examples the author has seen.

In the section is much calcite, some primary, but other parts are apparently secondary, replacing plagioclase felspar.

The usual inclusions and strain shadows are present in the quartz grains which are of both simple and complex types. Muscovite is also present.

* *Q.J.G.S.*, vol. LXXV., pt. 4, pp. 251-294 and pls. XV-XVIII.

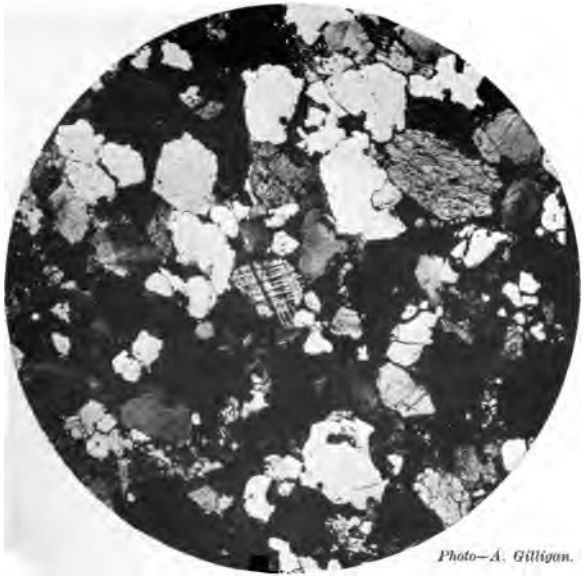


FIG. 1. Rough Rock from Borehole at a depth of 114 ft., Meanwood, Leeds. Crossed nicols. × about 20 diams.

FIG. 2. Rough Rock from Borehole at a depth of 125 ft., Meanwood, Leeds. Crossed nicols, × about 20 diams.

NOTES ON THE SECTIONS EXPOSED IN EXCAVATING FOR THE LEEDS INFIRMARY EXTENSIONS, 1916.

By A. Gilligan, D.Sc., B.Sc., F.G.S. and M. Odling, M.A., B.Sc., F.G.S.

The general outline of the section is plotted from detailed measurements made at varying intervals, a base level having been obtained partly by means of a water level and partly by means of a reflecting clinometer mounted on a camera stand.

General Vertical Succession.

The general vertical succession of the beds exposed, based on the mean thicknesses measured in about a dozen places along the principal section is as follows :—

Made Ground, varying in thickness and resting on different members of the series.

(*a*) Dark iron-stained shale	up to 2 ft.	5 ins.
(*b*) Grey shale ; with a band of ironstone nodules at the top and about 1 ft. 8 ins. from the base	3 ft.	9 ins.
(*c*) Impure coal	2 ft.	9 ins.
(*d*) Grey clay ; very persistent but varying somewhat in thickness		3 ins.
(*e*) Impure coal	1 ft.	3 ins.
(*f*) Clay, shale and impure coal, consisting of a persistent seam of clay, passing down into impure coal and shale. This series, whose total thickness is practically constant, varies considerably in different parts of the section ; the almost purely argillaceous base passing up through varying thicknesses of impure shaly coal into a comparatively pure coal with a band of clay generally at the top	1 ft.	5 ins.
(*g*) Impure coal ; with thin streaks of shale	1 ft.	10 ins.
(*h*) Grey shale ; persistent and forming a conspicuous feature		2 ins.
(*i*) Impure coal ; with a persistent film of clay near the centre	1 ft.	7 ins.
(*j*) Bluish grey clay (exposed for a few inches only in the principal section)	over 5 ft.	0 ins.
Total Thickness seen	about 20 feet.	

Throughout the section the coal is very impure, being largely contaminated by argillaceous material, and quite unfit for fuel; in some layers it might be described as a carbonaceous shale.

Notwithstanding the impurity of the coal the "Cleat" is well developed throughout, its trend being North 45° West-South 45° East. The clays directly underlying the coal seams invariably contains rootlets and thus constitute a true "Seat-Earth." The pale bluish colour of the basal clay, weathering rapidly to a brilliant sickly yellow suggests a high percentage of finely disseminated iron sulphide probably in the form of marcasite.

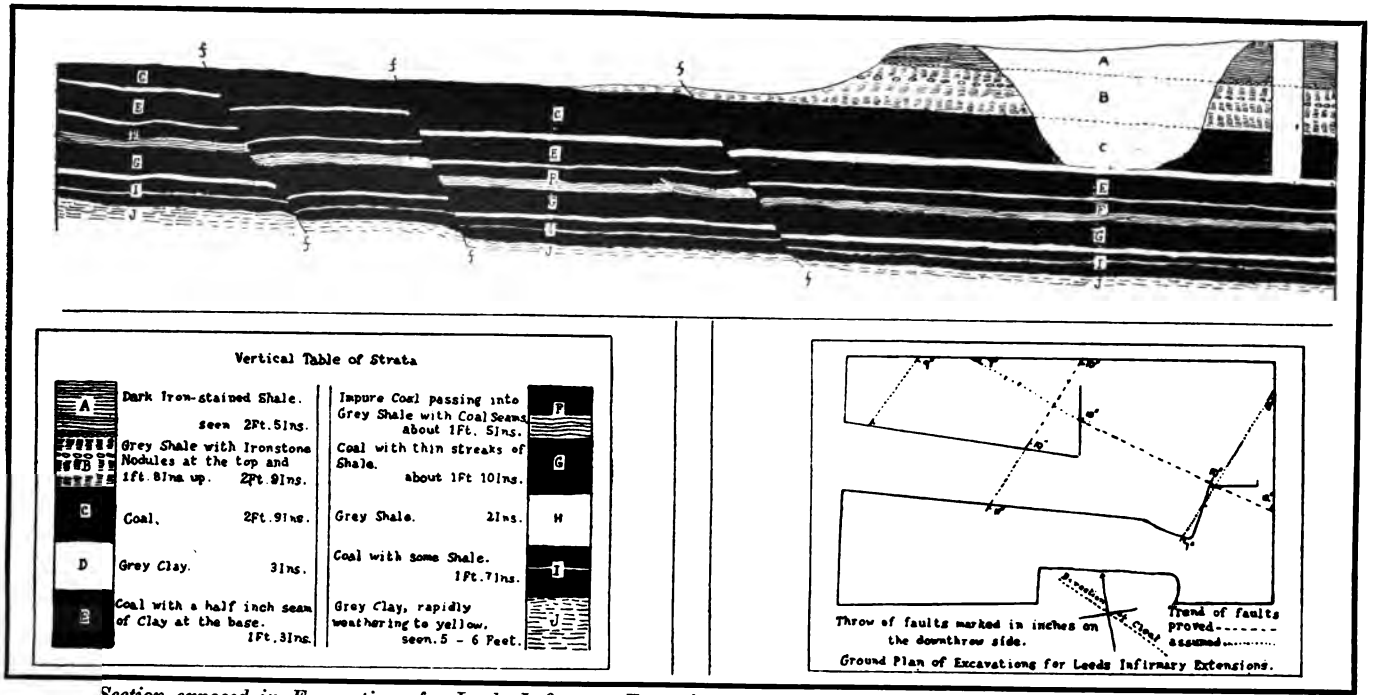
One of the most noticeable features throughout the exposure is the almost total absence (except for carbonaceous specks and rootlets) of plant remains, even the ironstone nodules failing to yield any recognisable specimens.

The exact horizon of the beds in which the excavations have been made is difficult to determine, but it appears to be about that of the measures in which the Crow Coal occurs, and which have been proved under Briggate.

On reference to the ground plan, it will be seen that faults have been traced in no less than twelve places around the sides of the excavation. When these are joined up on the evidence of hade and direction followed by fault planes as the work proceeded, it is found that four faults are really present, three of which are in a N.E.-S.W. direction and one in a N.W.-S.E. direction. These are the directions of the large faults in this part of the coalfield.

A noticeable feature is that the beds near the faults show a reversal of the curvature generally associated with normal faults. This is well seen in the photograph of the third fault. Yorkshire geologists will recall the well known Peak Fault (Ravenscar) as shewing similar features and attention has recently been directed to the fact that a similar reversal of curvature is found in connection with numerous faults in the Carboniferous rocks of the North of England.* Near to one of the larger faults a small overthrust was seen in the lower part of bed F. but was not traceable in any of the associated beds.

* Prof. Kendall and Dr. Gilligan, *Report of British Association for Advancement of Science*, Bournemouth, 1919.



Section exposed in Excavations for Leeds Infirmary Extensions, corner of Calverley Street and Fenton Street, Leeds.

Trans. Leeds Geol. Assoc. Part XVIII. Plate 3.

Photo—M. Odling.

FIG. 1. Photograph of the 3rd fault from the West in the principal section. The reversed curvature of the strata against the fault is well shewn.

Photo—M. Odling.

FIG. 2. Photograph shewing the movement in Bed F, West of the 3rd fault in the principal section.

Photo—M. Odling.

Fig. 3. Photograph of the 2 Western faults in the principal section.

Trans. Leeds Geol. Assoc. *Part XVIII.* *Plate* 5.

LEEDS INFIRMARY EXTENSIONS.

It will be noticed that the faults were not visible on the southern face of the excavation this being due to the fact that during previous excavations the upper beds containing the thin coals had been removed, and the faults could not be traced in the bed of clay which was exposed on this occasion.

REPORTS OF EXCURSIONS.

OTLEY.—June 6th, 1916 (evening). Leader, Mr. A. Gilligan, B.Sc., F.G.S. The party proceeded first to the Great Dib, the scene of extensive landslips. Some time was spent in examining the sections of grits and shales exposed in the quarries of Mr. J. H. Nunn, where fine examples of ripple markings, worm burrows, molluscan tracks and rain pittings were seen. A band of marine shale near the quarry yielded Goniatites, Pterinopecten, Orthoceras, Lingula, Modiola.

BRADFORD and SALTAIRE.—July 5th (evening). Leader, Mr. W. P. Winter, B.Sc. The course of the Bradford Beck, now covered in, was seen in the centre of the City. The Party took car to Allerton whence they walked to Saltaire by way of Chellow Dene and Nailer Rough, noting these and other glacial overflow channels and cols in the neighbourhood. The route lay over Lower Coal Measures and the upper beds of the Millstone Grit.

EXTRACTS from ANNUAL REPORT, 1916-17.

It was found advisable to hold only six meetings, as follows :—

1916.

Oct. 20—PRESIDENTIAL ADDRESS. J. H. EVERETT, B.Sc. : "The Black Sea" (*lantern slides and diagrams*).

EXHIBITS.

By THE STAFF OF THE GEOLOGICAL DEPARTMENT OF THE UNIVERSITY : A Model of the Grassington Mines, Microscope sections of Cherts and Flints, latest Maps and Memoirs, rock specimens and Fossils.

By Mr. O. MARSDEN : Early Geological Books.

Nov. 17—Mr. M. ODLING, M.A., B.Sc., F.G.S. : "A Geological Trip to Switzerland" (*lantern slides*).

EXHIBIT.

By Mr. ODLING : Some old Books on Geology.

Dec. 8—Mr. A. GILLIGAN, B.Sc., F.G.S. : "The Geology of Upper Wharfedale" (*lantern slides and specimens*).

1917.

Jan. 19 Professor P. F. KENDALL, M.Sc., F.G.S. : "The Geographical Evolution of Britain in Carboniferous Times" (*lantern slides*).

Feb. 16—Mr. G. GRACE, B.Sc., A.R.C.Sc. : "The Scenery of the Lake District" (*lantern slides*).

Mar. 16—ANNUAL MEETING. Report, Balance Sheet, Election of Officers, etc. Mr. A. GILLIGAN, B.Sc., F.G.S., read a "Note on the occurrence of the rare mineral Monazite in the Millstone Grit," and showed specimens.

Miss E. D. WHITAKER, B.Sc., gave a Review of the Ingletonian Series, and exhibited specimens.

Mr. C. T. WHITMELL, M.A., B.Sc., F.R.A.S., exhibited sections of Tourmaline.

LIBRARY.—. . . . The disposal of the continually accumulating stock of books and papers will demand careful attention as soon as times approach nearer the normal.

MEMBERSHIP.—. . . . So far as can be ascertained, 19 members and associates are serving in His Majesty's Forces. . . . .

REPORTS OF EXCURSIONS.

RAWDON.—June 20th, 1917 (evening). Leader, Mr. A. Gilligan, B.Sc., F.G.S. Tip heaps of old colliery workings were examined in the valley of Red Beck which was shown to be due to trough faults. The material had evidently come from the roof of the Black Bed Coal and yielded Lingula, Goniatites, Orthoceras and Pterinopecten. The drift of the area, all of local origin, was also examined.

ELLAND ROAD QUARRIES.—(Leeds Fireclay Co.), July 17th, 1917 (evening). Leader, Mr. J. H. Everett, B.Sc.

A full account of these quarries appears on page 33.

EXTRACTS from ANNUAL REPORT, 1917-18.

Four meetings have been held, as follows :—

1917.

Nov. 16—PRESIDENTIAL ADDRESS. Professor P. F. KENDALL, M.Sc., F.G.S. : "Geology and Water Supply" (*lantern slides*).

EXHIBITS.

By THE STAFF OF THE GEOLOGICAL DEPARTMENT OF THE UNIVERSITY : A collection of Minerals made by the late Mr. J. Westmoreland, one of the founders of the Association. Coal Measure Fossils, Slides of Diatoms and Foraminifera.

Dec. 14—Miss E. D. WHITAKER, M.Sc. : "Peat Problems" (*lantern slides*).

EXHIBIT.

By THE PRESIDENT (Professor KENDALL) : A Set of Sections, showing a complete section of the Barnsley Bed at Hickleton Main. The sections were cut by Mr. J. Lomax and presented to the University by Sir W. E. Garforth.

1918.

Feb. 15—Mr. A. GILLIGAN, M.Sc., F.G.S. : "Deltas, Past and Present" (*lantern slides*).

Mar. 15—Dr. T. W. WOODHEAD, Ph.D., M.Sc., F.L.S. : "The Ecology of the Coal Flora" (*lantern slides*).

EXHIBIT.

By THE PRESIDENT (Professor KENDALL) : Microscope Slides of Sections of Rhynia Gwynne-Vaughani from the Middle Old Red Sandstone of Scotland, one of the latest discoveries in palaeo-botany.

On March 19th, the President of the Association (Prof. P. F. Kendall, M.Sc., F.G.S.) lectured to the Leeds Philosophical and Literary Society on "The Rivers of the Coal Age." By invitation of the President of that Society (J. E. Bedford, Esq., F.G.S.) a large number of our members attended.

PEAT PROBLEMS.

Paper read by MISS E. D. WHITAKER, M.Sc., *14th December*, 1917.

Peat is an accumulation of vegetable debris, often very perfectly preserved, formed by the growth and incomplete decay of a moderately luxuriant vegetation. Abundant moisture is essential for the preservation of plants in the form of peat, because water restricts the access of air and so tends to preserve plant tissues by excluding the aerobic agents of decay. Hence peat formation demands either a wet climate or the conservation of available water by impeded drainage.

The range of peat is cosmopolitan ; it occurs in all kinds of situations, and it may be composed of any variety of plant, from forest trees to unicellular algae and fungi.

Professor Stevenson, in his " Inter-relations of the Fossil Fuels " says that " The area of Quaternary and Recent peat deposits is apparently greater than that on which carbon deposits were laid down during any preceding period of similar duration." Ireland alone has an estimated area of 3,000,000 acres of peat, varying from a few inches to 40 feet in thickness.

In Britain we have upland peat moors in Scotland, the Lake District, the Pennines, on Dartmoor, etc., and also low-lying mosses at Sedgemoor, in Lonsdale, the Fen District, and at Thorne and Hatfield near Doncaster. At various points round our coast are submerged forests, or peat beds lying below high tide level and proving the former wide extension of wooded areas, and the subsequent lowering of the land level by many feet. Lumps of peat or " Moorlog " are dredged from the floor of the North Sea, and this material, like the submerged forests, must have been deposited before the great submergence took place.

Peat, as a rule, is a distinctly stratified deposit, but this stratification is not due to the sorting and deposition of the constituents in water, but usually to the natural growth and fall of successive generations of plant remains, and to the succession on the same spot of different plant associations. Each association leaves its incontestible record in the plant remains forming the successive horizons in the peat. The incoming of new plants and the dying out of communities may be due to fluctuations of climate,

to the blocking or facilitating of drainage by any means, or to the chance introduction of a new dominating species into the region. It is important to remember that the surface vegetation of to-day may be the peat of a year hence and the coal of the next geological period.

Many plants such as Sphagnum and Eriophorum vaginatum, have the property of continuing their growth upwards, while their old bases are left behind and become incorporated with the dead peat below.

All peat taken from a living bog—that is one still covered with growing vegetation—contains a high percentage of water, often 80-90%. Some of this water is interstitial, but much of it is contained in the perfectly preserved cells of the plants, and it is this water which will not drain away that constitutes a great problem in the practical working of peat deposits. Hydraulic pressure, centrifugal machines and other devices have been tried but no really quick, cheap and efficaceous method has been found up to the present.

Peat problems may be divided into two classes :—Scientific and Commercial. The two are inextricably bound up with one another—certainly all commercial development should be based on careful and detailed scientific investigation.

By its abundance and wide distribution peat is entitled to rank as a geological stratum, and though it is comparatively recent in origin it may be expected to throw much light on various problems in late geological history, as well as providing invaluable analogies to the conditions of deposition and the peculiarities in the nature and composition of more ancient and altered peat deposits such as the great coal beds of the Carboniferous series.

The occurrence of Arctic-Alpine associations at the base of many peat mosses in Northern Europe indicates that much of the peat began to form in late Glacial times. Sometimes more than one Arctic bed occurs, separated by peat composed of plants characteristic of milder conditions. This indicates fluctuations of climatic conditions following the disappearance of the ice sheets. Some authors readily ascribe *all* changes of flora in the peat to climatic

variations, but such evidence should be received with extreme caution, as the change may be due to a purely local alteration of physical conditions, or to the initiation of a new stage in the history of floral distribution in the area.

The examination of serial sections of peat is invaluable for purposes of experiment, deduction and correlation. An investigation of the Harwood Dale Bog, on the North-East Yorkshire moors revealed an interesting succession. The bog lies in a shallow depression in the Moor Grit, at an altitude of 650 feet, and in spite of its small area (36 acres) shows all the characters of a typical High Moor bog. The greatest depth recorded by boring was just over 19 feet, but the section was taken down the face of the cuttings at a place where the thickness of the deposit was about 16 feet. The peat was treated with 25% Commercial Nitric Acid until thoroughly loosened and disintegrated and was then washed and examined with lens and microscope. A notable feature of this bog was the large collection of stools of trees at the base of the section. Unmistakable remains of Scots Pine, Birch, Oak, Rowan and Hazel were seen. The Section showed the following layers :—

4. Surface Vegetation.—Eriophorum, Sphagnum, Ericaceous plants, large patches of Calluna invading the drier portions of the surface.
3. Top Layer.—About 10 feet. Sphagnum, Eriophorum vaginatum, Ericaceous plants, etc., indicating a long period of typical Sphagnum bog, with wet conditions and free peat formation.
2. Forest Layer.—About 4 feet. Many twigs, stools and roots of trees, latter in position of growth ; also Pine Cones and Hazel Nuts. This stage indicates drier conditions, and was of fairly long duration as is proved by the presence of over 100 annual rings in some of the Pine stumps.
1. Fen Layer.—A few inches to 2 feet. Scirpus, Juncus, Phragmites, etc. A vegetation typical of the gradual filling in of a shallow pool, held up by the fine clay which an analysis made by Dr. Gilligan proved to be a wash from the surrounding slopes of Moor Grit.

There is no need to invoke any change of climate as a cause for the succession indicated above. The natural filling in and solidification of a marsh, followed by the partial desiccation of the surface, would form a layer capable of supporting the early growth of the trees of which the roots later penetrated the sub-soil. It is interesting to note that the earliest and most abundant trees were those with winged seeds—notably Pine and Birch.

The end of the Forest stage may have been due to some very small cause, such as the impeding of the drainage of the hollow by fallen trunks. Sphagnum and Eriophorum spread, and finally the Sphagnum—Cottongrass moor which persists till the present day was established.

A record by Mr. Munn Rankin in Tansley's "Types of British Vegetation" shows a strong similarity of sequence in the plant remains of the Estuarine Moors of Lonsdale. The Author's own sections at Thorne and Hatfield and on the Ilkley Moors give further evidence that the sequence is a common and normal one. Any definite correlation of plant sequences in the different peat beds of the country would be of wide interest and significance, as it might make possible the working out of the parts played by climatic changes, variation of land-level and other important factors in recent geological history.

The Submerged Forest, perhaps more than any other peat deposit, may be expected to yield parallels to the conditions governing coal formation; indeed the section through the beds of peat and silt at Leasowe presents a marked resemblance to a Coal Measure section.

Some of the coal problems which a study of peat may help to solve are those connected with stratification, rate of growth, origin, nature and properties of underclay, effects of heat and pressure, variation of plant constituents and physical characters, and the source, origin and percentage of ash.

An examination of 33 results of ash determinations of peat from different levels and localities led the writer to the conclusion that the ash content of peat, and therefore probably of coal also, is governed by the following factors:—

(1) Physical conditions, such as the amount of available mineral matter, the slope, and the amount of water draining into the bog, etc.

(2) Differences in depth of peat—the earliest formed layers usually showing a higher ash content than those deposited after a dense growth of vegetation has provided a filter for suspended material as it enters the bog.

(3) Difference of plant constituents, e.g., trees have a higher ash content than have mosses.

(4) Some plants give up much mineral matter when they become peat. These substances pass into solution and are leached out as food for successive generations of surface vegetation. Hence the ash content of some peat is lower than that of its constituent plants.

From an economic point of view the most serious obstacle to the working of peat has been the difficulty of eliminating the excessive water content of the raw material. Cells of Sphagnum and other bog plants are singularly indestructible, being found in perfect condition at a depth of 12 or 14 feet, and remaining practically uninjured, after subjection to a pressure of 50 tons per square inch of a block of peat containing them. Up to the present some form of air-drying on the bog seems to be the most satisfactory and general method, though it has disadvantages in the shape of dependence on weather conditions, length of time required, labour involved, and risk of fire. The peat takes many months to dry, and after this process is complete it is used in blocks for fuel, or disintegrated and used for moss litter, packing material, briquettes and many other purposes.

The bulk of peat in proportion to its dry weight makes the problem of transport a serious one, particularly in the case of small and inaccessible bogs. Such deposits, though unsuitable for commercial development, may serve a useful purpose by supplying local needs.

It seems probable that the future of peat lies largely in the direction of utilization as a source of chemical products (tar, ammonia, oils, creosote, asphalt, paraffin wax, acids, alcohols, etc.), or for the production of electricity.

ANNUAL REPORT, 1918-19.

Your Council has to report that owing to continued restrictions in various directions, and the increasing number of members joining His Majesty's Forces or engaged on other War Work, the Session has had a somewhat chequered existence. It was not found practicable to arrange the usual syllabus, but three meetings were held as follows :—

1918.

Nov. 22—ANNUAL MEETING of the 44th Session, and Opening Meeting of the 45th Session. Report, Balance Sheet, Election of Officers, etc.

EXHIBITS.

By Dr. A. GILLIGAN, D.Sc., F.G.S. : A Series of Lantern Slides from the Bingley Collection, illustrating the Borderland of the Craven and Pennine Faults.

By THE PRESIDENT (Professor KENDALL) : Maps, Specimens and a complete series of microscope sections of the Barnsley Bed.

1919.

Jan. 17—PRESIDENTIAL ADDRESS. Professor P. F. KENDALL, M.Sc., F.G.S. "New Light on some Coal Problems."

Mar. 21—Dr. A. GILLIGAN, D.Sc., F.G.S. : "The Petrography of Sedimentary Rocks" (*lantern slides and specimens*).

Considering the prevailing conditions, the meetings were well attended. The papers and exhibits were of great interest.

Unfortunately no excursions could be arranged, though members had the opportunity of attending those of the Yorkshire Naturalists' Union.

LIBRARY.—The publications of various Societies and Institutions have been received mostly as usual, including the Q.J.G.S. kindly presented by Mr. Arnold Lupton. Dr. David Forsyth has made a valuable gift in the shape of a number of back parts of the Association's Transactions, including some now out of print.

MEMBERSHIP.—The continued absence of many members makes it difficult to give the exact number of effective members. Two members and one associate have joined during the session.

The Association, in common with many other local Scientific Societies deeply regrets to record the death of Mr. W. Denison Roebuck, M.Sc., F.L.S., its senior member, who acted as Honorary Auditor for many years. Two members have been lost in the Empire's service—Mr. Herbert King, M.Sc., F.I.C., F.C.S. being killed in action, and Mr. Wm. Long having died whilst on Active Service.

In conclusion, your Council expresses the thanks of the Association to those who have read papers or exhibited specimens or slides at the meetings, to Dr. Forsyth, Mr. A. Lupton and other donors to the Library, to the Authorities of the University for allowing the use of the rooms, and to the Members of the Staff of the Geological Department of the University for their continued active support.

EXTRACTS from ANNUAL REPORT, 1919-20.

Six evening meetings have been held, as follows :—

1919.

Nov. 7—ANNUAL MEETING of the 45th Session, and Opening Meeting of the 46th Session. Report, Balance Sheet, Election of Officers, etc.

Dr. A. GILLIGAN, D.Sc., F.G.S., exhibited and described lantern slides from the Bingley Collection, illustrating the Geology of Wharfedale and Nidderdale.

EXHIBITS.

By THE STAFF OF THE GEOLOGICAL DEPARTMENT OF THE UNIVERSITY : Maps and Aero-photos of the Jordan Valley, Maps and Specimens from the Dublin Area, Silurian Fossils from Moffat, Pebbles from the Bunter Pebble Beds of Staffordshire and Cheshire, Magnesian Limestone, etc., from the Scunthorpe boring, Oolitic Granules from an Ammonia Scrubber.

By Mr. C. T. WHITMELL, M.A., B.Sc., F.R.A.S. : Crinoidal Chert from a Moraine near Ilkley.

Dec. 5—PRESIDENTIAL ADDRESS. Professor P. F. KENDALL, M.Sc., F.G.S. : "Problems of Local Geology" (*lantern slides*).

1920.

Jan. 16—Mr. C. A. CHEETHAM : "The Austwick Peat" (*lantern slides and specimens*).

Messrs. J. H. EVERETT and G. F. PICKERING : "Notes on the Elland Road Sections."

Feb. 27—Mr. W. S. BISAT : "The Land Surface of Yorkshire in Permo-Carboniferous Times" (*maps, diagrams and photographs*).

Mar. 19—Dr. A. GILLIGAN, D.Sc., F.G.S. : "The Iron Ores of the British Isles" (*lantern slides, specimens, etc.*).

Apr. 16—ANNUAL MEETING. Report, Balance Sheet, Election of Officers, etc.

Mr. J. N. CARRUTHERS : "Recent Observations on the Red Rock of Rotherham."

Mr. J. MADEN, B.Sc. : "Recent Observations on the Permian Escarpment South of the Aire."

On March 16th, Councillor E. Hawkesworth gave a lecture to the Leeds Philosophical and Literary Society on "The Geological Collections of the Society." A number of our members attended this lecture by invitation of the President of that Society (Sydney D. Kitson, Esq., M.A., F.S.A., F.R.I.B.A.).

. . . . Your Council has under consideration the housing of the Library in some place accessible to the members.

MEMBERSHIP.—There is a falling off since pre-war times. The numbers to date are :—

Honorary Members	8
Ordinary Members	60
Country Members	9
Associate Members	10
Total	87

Four Members and seven Associates have joined the Association during the Session.

Your Council records with deepest regret, the death of Mr. C. T. Whitmell, M.A., B.Sc., F.R.A.S., who rendered the Association many valuable services during his long period of membership extending over 22 years. He was President from 1909 to 1911.

In conclusion, your Council offers its sincerest thanks to all those who have read papers or exhibited specimens at the meetings, to the President of the Philosophical and Literary Society for his kind invitation to attend Councillor Hawkesworth's Lecture, to Mr. A. Lupton and other donors to the Library, to Mr. A. Abbott for auditing the accounts, to the University Authorities for granting the use of the Meeting Room, and especially to the Staff of the Geological Department of the University for much generous help, always readily and cordially given.

CASH ACCOUNT to 20th August, 1920.

Cr.

Receipts.	£	s.	d.
Balance from last Account	47	1	4
Subscripions and Arrears	20	16	6
Bank Interest *less* charges	0	17	11
Sale of Transactions	0	1	8
Owing to Treasurer	0	4	7½
	£69	2	0½

Dr.

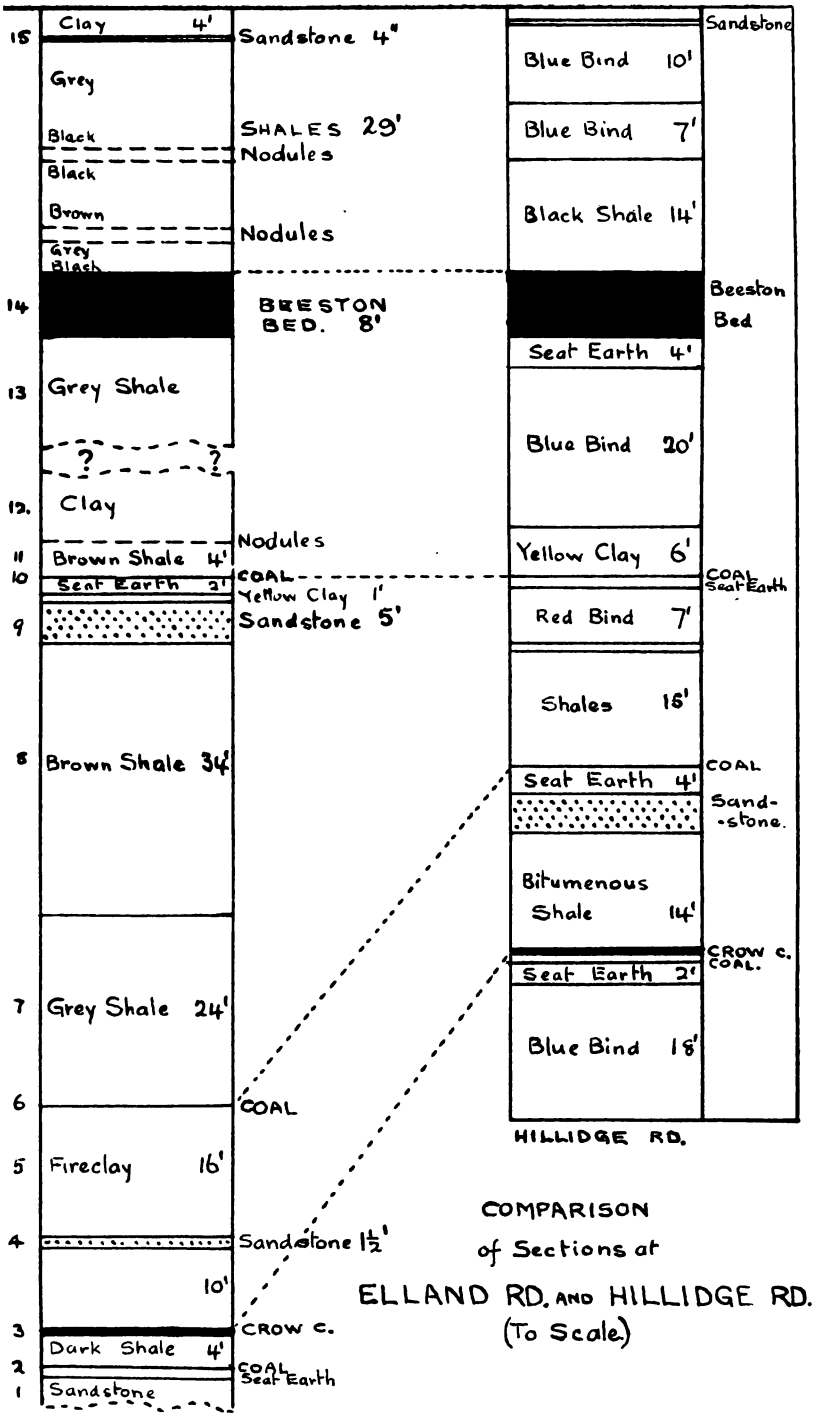
Expenditure.	£	s.	d.	£	s.	d.
Printing and Stationery				8	8	9
Postage				2	7	11½
Leeds University				2	2	0
Yorkshire Naturalists' Union ..				0	18	5
Cash in Bank	45	18	11			
War Savings Certificate for £12 at cost	9	6	0			
				55	4	11
				£69	2	0½

BALANCE SHEET.

Assets.	£	s.	d.
Subscriptions unpaid, estimated at	1	0	0
Cash in Bank	45	18	11
War Savings Certificate	9	6	0
	£56	4	11

Liabilities.
NIL.

Examined, compared with vouchers and found correct.
18th November, 1920.
A. ABBOTT, *Hon. Auditor.*



Trans. Leeds Geol. Assoc. Part XVIII. Plate 6.

NOTES ON SOME SECTIONS IN ELLAND ROAD, LEEDS.

By J. H. Everett, B.Sc. *and* G. F. Pickering.

The strata to be described are in the Lower Coal Measures, and occur on the steep slope of " Beggars Hill " on the south side of the Elland Road about 1¼ miles from the centre of Leeds (Plate 7). They comprise a total thickness of about 170 feet, from some 20 feet below the Crow Coal to 30 feet above the Beeston Bed, and at the same time they form a complete section up the hillside (Plate 6).

These beds are on the upthrust side of a fault across the " summit " of Beeston Hill, in an approximately S.W. to N.E. direction ; the throw is 22 yards.

Attention is drawn to the plate showing a comparison of this Elland Road Section with that occurring in Hillidge Road, Hunslet, about one mile E.N.E., apparently on the other side of the fault (see Six Inch Map, Yorkshire, Sheet 218), and described in Part 14 of the Transactions. It should be noted that there is a vertical difference of level of about 150 feet between the sections of the Beeston Bed at these two places. Much of the surface between is covered by alluvial gravels of the Aire Valley.

The sections at Elland Road are worked for fireclays mainly, but they have yielded Coal also. The lowest beds of all (below the Crow Coal) were found in Messrs. Woolley's Quarry (Plate 7, A.) from the floor of which the Crow Coal has been largely removed. This quarry contained beds 1 to 11. Exposure B (Pl. 7, fig. 2) contained beds 10 to 12. At C occur beds 13 and 14, while beds 14 to 18 were exposed at D.

Bed No. 1 is a sandstone the base of which cannot be seen. Above this comes a 4-inch seam of coal (" Johnnies ") underlain

by a Seat Earth and capped by 4 feet of dark shale above which lies the Crow Coal (1 ft. 1 in. thick, true dip, about 3° in a direction 10° E. of N. Mag.); between the Crow Coal and bed No. 4 which is a sandstone, come 10 feet of strata which were only visible on one occasion, when it was apparently being worked as a fireclay. The sandstone contains abundant ripple marks and curious concretions referred to by the workmen as "arms and legs"; No. 5 is a fireclay containing many fine rootlets, and this is succeeded by a thin layer of coal (1 in. to 2 in.), above and below which is 4 ins. of black shale. Formation No. 7 is grey shale about 25 ft. in thickness, in the middle of which irregular patches of gannister (?) are reported as occurring, showing cone-in-cone structure. On one occasion moisture was observed to be draining down the sides of the quarry from the junction between beds 7 and 8. The 34 feet of brown shale is succeeded by 5 ft. of sandstone (No. 9), above which come 1 ft. of yellow clay, and 2-3 ft. of fireclay (a Seat Earth seen best at exposure B, where it contained Stigmaria and rootlets, the former in some cases descending immediately from the overlying 3 ins. of coal).

Bed No. 10 is interesting as having enabled us to correlate the beds in exposures A and B. (the latter was worked by the Leeds Fireclay Co.), for this 3 ins. of coal occurred in both sections. There were also shown at exposure B, No. 11, a brown shale containing nodules, and No. 12, a clay, which two beds are separated by a continuous band of nodules.

Between exposures B. and C. occurs the only gap in the full sequence up the hillside, but from surface observations on various parts of the slope, and from the use of the Abney Level, the authors conclude that the unobserved strata cannot be more than about 10 feet in thickness.

At exposure C., 13 feet of hard grey shale can be seen together with the base of the Beeston Bed, the main part of this latter seam having been removed many years ago. The seam enabled us to cross to exposure D. where the Beeston Bed has been worked out

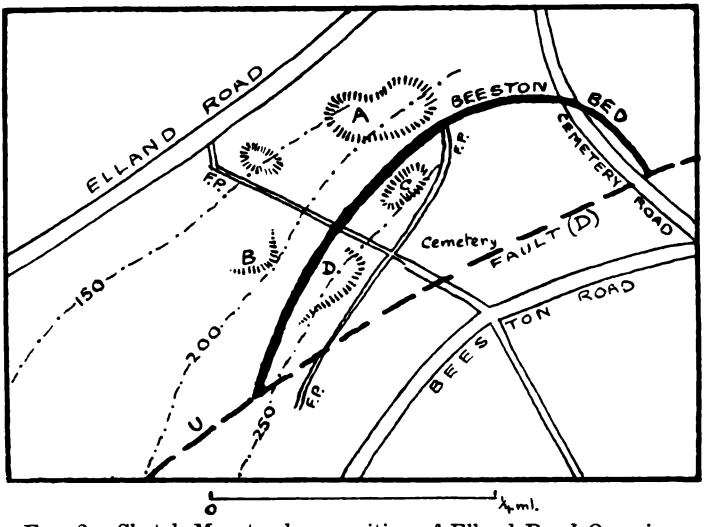


FIG. 2. Sketch Map to show position of Elland Road Quarries.

FIG. 3. Photo showing Beeston Bed with Partings.
Trans. Leeds Geol. Assoc. Part XVIII. Plate 7.

along its outcrop by the Leeds Fireclay Co. The details of this famous coal seam were approximately as follows :—

Coal ..	2′ 6″			
Parting ..				3″
Coal	1″ 3″			
Parting ..				1″
Coal	7″			
Parting ..				1½″
Coal	4″			
Parting ..				3″
Coal	9″			
Parting ..				½″
Coal	2″			
Parting ..				½″
Coal	10″			
Parting ..				1″
Coal	1′ 1″			
Totals ..	7′ 6″	and		10½″

The observed dip was 2°—3° into the hillside (*i.e.*, towards the fault).

Above the Beeston Bed come 29 feet of Shales as follows :—

Sandstone		4 ins.
Grey Shale	10 ft.	
Black Shale	9 ft.	
Brown Shale	4 ft	3 ins.
Grey Shale	3 ft.	10 ins.
Black Shale		7 ins.
Grey Shale		5 ins.
Black Shale		7 ins.
Beeston Bed.		

with four 1 inch nodular bands at intervals of 4 ft., 5 ft. 6 in., 14 ft., and 15 ft. 6 in., measured respectively from the top of the Coal. Succeeding these shales come 4 ins. of sandstone, and then about 4 feet of clay.

The cleat in the various Coal Seams worked out as follows, all, except "No. 6," being averages of a number of readings :—

(1) Beeston Bed .. .. 23° W. of N. Magnetic).
(2) Bed No. 10 .. .. 15° ,, ,, (,,).
(3) Bed No. 6 .. .. 25° ,, ,, (,,).
(4) Crow Coal .. .. 28° ,, ,, (,,).

Apart from rootlets in the Seat Earths (at times abundant), practically no fossils have been found in any of the beds up to the present.

REPORTS OF EXCURSIONS.

CLAYTON WOOD, HORSFORTH.—May 12th, 1920 (evening). Leader, Dr. A. Gilligan, D.Sc., F.G.S. The sequence of Millstone Grit and Coal Measures exposed in Messrs. Briggs' and Messrs. Whitaker's quarries was examined, especially the junction of the Grit and Coal Measures in the latter quarry; and a fossiliferous marine shale was observed although it failed to yield any recognisable species. The effect of faulting on the configuration of the country was noticed in a tributary to Horsforth Beck.

CASTLEFORD AND PONTEFRACT.—June 5th. Leaders, Messrs. J. Maden, B.Sc. and H. C. Versey, M.Sc. The basal beds of the Permian formation and the Lower Magnesian Limestone were examined along the escarpment from Red Hill, Castleford, to St. Thomas' Hill, Pontefract. The conglomerate, discovered by Mr. Maden, between the sands (used in the industries of the district) and the Limestone, was found to contain merely local pebbles (of Carboniferous rocks) showing some attempt at stream laying. Of special interest is the fact that such a small stream as Fryston Beck cuts right through the whole escarpment. The Windmill Quarry, St. Thomas' Hill, yielded Schizodus obscurus, together with annelid-like markings, while Bakewellia was fairly common in many of the quarries; the yellow sands at St. Thomas' Hill showed dune-bedding. In a quarry east of Fairy Hill the limestone showed current bedding, a feature not common in limestone.

ROBIN HOOD QUARRIES.—June 15th (evening). Leader, Mr. J. H. Everett, B.Sc. For a detailed account of these quarries see Part 17 of the Transactions. On the occasion of this visit it was found that the workings had developed in such a way that several notable geological features were not nearly so well exposed. Nevertheless the quarries still exhibit a large number of things of interest to the geologist. A noticeable new feature was the discovery of a definite, but probably local, fossiliferous zone occurring about 9 ins. below the hard sandstone (No. 8, Plate 2, Part XVII.). This very thin zone was crowded with Calamites. Some fine specimens of Lepidostrobus in hard gray nodules were also found, having come from either Bed 11 or Bed 13.

ACKTON HALL COLLIERY.—June 30th (evening). Leader, The President (Prof. P. F. Kendall, M.Sc., F.G.S.). The "split" in the Silkstone Seam was examined; it is explained by the action of a river, contemporaneous with the formation of the seam, which has scoured out the material. All the phenomena of "lurching" of strata due to contemporaneous earthquake action were also seen, as well as beds of cannel coal, a conglomerate with ironstone pebbles, and an exceptionally fine suite of Stalactites of Salt; these latter showed all stages of formation, and some were elongated in the direction of the air current.

MARSDEN.—July 10th. Leader, Dr. T. W. Woodhead, Ph.D., M.Sc., F.L.S. Various exposures were examined in the neighbourhood of Meltham and Marsden, with the following results:—The shales below the Rough Rock at Dolly Folly fault near Meltham yielded Gastrioceras listeri, etc. Shales at Royd Bridge and Brow Grains below Rock A. of Survey yielded Glyphioceras bilingue in profusion. Shales at probably the same horizon were seen at Bradley Brook, near Holt Head. A marine band with lamellibranchs, somewhat lower in the series, was seen in a quarry on the Slaithwaite-Holt Head Road. Shales with G. reticulatum in abundance (in nodules) were seen near Slaithwaite, also near Marsden. Still lower, shales with Lingula and lamellibranchs were seen in the Wessenden Valley at Butterley Reservoir.

SEVEN ARCHES, ADEL.—July 14th (evening). Leader, Mr. B. J. Smith. In the course of excavations, a sequence of beds from the 3rd Grit to the Rough Rock had been exposed; the gannister beds of the Middle Grit and the marine shales below the Rough Rock Flags were examined. The Drift beds which were exposed in various places were very difficult to understand; more work should be done in these interesting sections.

THE LIBRARY.

The Books belonging to the Association are at present, by the courtesy of the University authorities, stored in the Department of Geology of the University, and are in the care of the Honorary Secretary of the Association, who is always glad to arrange for the loan of them to Members, on suitable notice being given, and postage, etc., paid.

Besides a number of miscellaneous pamphlets, sets of Transactions, etc., and a few books, such as Tate and Blake's "Yorkshire Lias"; Lyell's "Principles of Geology"; Phillips' "Yorkshire Coast"; Mantell's "Pictorial Atlas of Fossils"; the following are received as published :—

"The Naturalist" (monthly).
"The Quarterly Journal of the Geological Society of London" (*presented by Mr. Arnold Lupton*).
"The Proceedings of the Geologists' Association" (London).
"The Proceedings of the Yorkshire Geological Society."
"The Transactions of the Liverpool Geological Society."
"The Transactions of the Leeds Astronomical Society."
"The Transactions of the Hull Geological Society."
"The Transactions of the Edinburgh Geological Society."
"Summary of Progress of the Geological Survey."
"Journal of the Manchester Geographical Society."
"Memoirs of the Manchester Literary and Philosophical Society."
"British Association Reports."
"Records of the Australian Museum."
"United States Geological Survey—Bulletins, Professional Papers, and Monographs."
"Reports of the Smithsonian Institution." Etc.

LEEDS GEOLOGICAL ASSOCIATION.

Forty-Seventh Session, 1920-21.

OFFICERS.

President :

Professor P. F. KENDALL, M.Sc., F.G.S.

Vice-President :

J. H. EVERETT, B.Sc.

Hon. Secretary :

H. C. VERSEY, M.Sc., University, Leeds.

Hon. Treasurer :

G. F. PICKERING, Woodcroft, Newlay Lane, Horsforth, Leeds.

Members of the Council :

A. ABBOTT.
C. A. CHEETHAM.
D. FORSYTH, M.A., D.Sc., LL.D.
G. A. GERMAN, M.Sc., F.G.S.
F. W. BRANSON, F.I.C.
GREEVZ FISHER.
A. GILLIGAN, D.Sc., B.Sc., F.G.S.
E. HAWKESWORTH.
Miss M. E. JAGGER, M.Sc.

List of Members for Session 1920-21.

*Those who have contributed Papers or conducted Excursions are distinguished by an asterisk.**

Honorary Members.

Year of Election.

1886 *Horne, Wm., F.G.S., Leyburn.
1891 *Marr, J. E., D.Sc., F.R.S., F.G.S., Cambridge.
1874 *Miall, Prof. L. C., F.R.S., F.G.S., F.L.S., Letchworth.
1887 *Sollas, Prof. W. J., M.A., D.Sc., LL.D., F.R.S., F.G.S., Oxford.
1890 *Woodward, A. Smith, LL.D., F.R.S., F.L.S., F.G.S., British Museum (Natural History), London.
1896 *Groom, Prof. T. T., M.A., D.Sc., The University, Birmingham.
1907 *Bond, J. W., Torre Road, Burmantofts, Leeds.
1902 *Thompson, Prof. G. R., B.Sc., F.G.S.

Ordinary Members.

1904 Abbott, A., 2, Langdale Terrace, Headingley.
1913 Barker, Mrs. H., 12, Cranbourne Road, Bradford.
1919 Barker, R. J., Woodland View, Purston, Pontefract.
1904 Beahan, J. J., City Engineer's Office, Leeds.
1918 Bedford, Arnold, Waterloo Main Colliery, Leeds.
1882 *Bedford, J. E., F.G.S., Shire Oak Road, Headingley.
1889 *Bingley, Godfrey, Thorniehurst, Shaw Lane, Headingley.
1920 *Bisat, W. S., 1, Selwyn Avenue, North Ferriby, Hull.
1908 Booth, Peter, 2, Wentworth Terrace, St. John's, Wakefield.
1908 Branson, F. H., Myrtle Cottage, Talbot Road, Roundhay.
1883 *Branson, F. W., F.I.C., 8, Wynneholme, Far Headingley.
1909 Broadbent, F. G., Croft House, Mirfield.
1916 Brown, T., M.Sc., Mining Dept., University of Leeds.
1918 Burrell, W. H., F.L.S., 44, West View, Horsforth.
1916 *Chapman, Miss S. E., B.Sc., City of Leeds Training College.
1905 *Charlesworth, A., M.Sc., Brunswick Avenue, H.G. School, Hull.
1906 *Cheetham, C. A., "Wheatfield," Old Farnley, Leeds.
1906 *Crowther, Hy., F.R.M.S., The Museum, Park Row, Leeds.
1896 *Dwerryhouse, A. R., D.Sc., F.G.S., University College, Reading.
1910 Ellison, F., B.Sc., 3, Airedale Terrace, Stourton, Leeds.
1905 *Everett, J. H., B.Sc., 113, Cross Flatts Grove, Leeds.
1911 Fisher, Greevz, 78, Chapel Allerton Terrace, Leeds.
1916 Fisher, Mrs. Greevz, Do.
1891 *Forsyth, D., M.A., D.Sc., LL.D., 101, Caledonian Road, Leeds.